Forty Years with General Electric

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FORTY YEARS WITH GENERAL ELECTRIC

I

To Begin With

A CORPORATION, it is often said, has no soul. The assertion may or may not accord with truth, but it is too sweeping to be accepted wholly without challenge. Many an oracular utterance has a long run more because no one takes the trouble to analyze it than because its substance is valid.

What is a corporation? In reality it is an assembly of human beings. And, as all authorities on spiritual matters allege, human beings have souls. They may not be able categorically to explain what a soul consists of, but that is another matter.

To assume, therefore, that, in the merely legal process of incorporation, souls incontinently leave their moorings and vanish, is hardly warranted. A more logical assumption is that they remain intact, but become homogeneous, and maybe more or less plastic, to suit corporate purposes. Such an assumption, too, is comforting to anyone prone to seek for the bright side of a situation. In the present case it tends to drive away a doleful thought —the thought that when two or more human beings

unite for business ends, their souls forthwith become null and void.

The sketches contained in this book were written on my own initiative. The job of writing them was not an assignment. Unlike much of the printed material about corporation affairs, they have, therefore, had neither the benefit, nor what a pessimist might call the blight, of official review or revision. If they are marred by defects, the defects are mine. If they possess merit, the merit, too, is mine. But apart from all that, I hope that the picture they present will be found to be quite different from that of a soulless corporation.

And that hope, I hasten to confess, springs from one form of self-interest. If the General Electric Company has been a spiritual nullity, the inference must be that it has made me one, and that I am, therefore, in a sorry predicament. I could not well have remained in its employ for so long a period as I have, more than forty years, without becoming like it. In other words, I could not have kept from atrophy the soul which my early tutors solemnly told me I possessed in common with other members of the species, male and female.

So I again express the hope that a soul will be perceptible in the corporation of which I have been moved to write. And I repeat that the hope is in one sense a selfish one. Having worked for wages, and punctually received them, I cannot deny,

indignantly or otherwise, that I have been a corporation hireling, although that term somehow grates upon my sensibilities. With a little effort one can think of politer terms. Calling an individual a corporation servant, for example, leaves him unruffled, and even smug, for service has become ultra-fashionable, the word itself frequently appearing on illuminated signs, on the insignias of respectable trades, and in capital letters in printed material.

However, terms are not of cardinal importance. What I mainly wish is to be spared the anguish popularly understood to be the lot of an atrophied soul, or, as it is defined in the lexicon of theology, a lost soul.

Thus, while anyone wishing to know what these pages tell will necessarily have to read them, of one thing a reader may be certain at the start. They do not exhibit the institution which I have known as the General Electric Company as an institution without a soul. They tell of machines, and of men who have made machines, but they are not darkened by the shadow of a Frankenstein monster.

II

A Measure of Growth

THE GENERAL ELECTRIC COMPANY is familiar to many as a mammoth industrial unit. Its early history, however, is intimately known to but few. The fierce light that now beats upon it is due in a large measure to the spectacular rise, in recent years, of the market value of its stock.

While dining some months ago with a boyhood chum whom I had not seen for nearly a quarter of a century, I perceived that while his knowledge of the General Electric Company's work was meager, he had closely followed the record of its stock.

"You ought to be rolling in wealth," he said, when I mentioned that I had been in the service of the corporation for forty years.

There ensued a dialogue the substance of which, as I am able to recall it, is relevant here as background material for my narrative.

"I've never had any feverish ambition to roll in wealth," I explained, "and, as a consequence, am unfamiliar with the operation. I make that assertion without any pretense of high-mindedness and solely from a desire to say what is so. As I look back I can see that I had many opportunities to make 'barrels

of money', but once a year, when the task of compiling my income tax has to be performed, it becomes evident to me that, with a complacency that now seems unaccountable, I let the opportunities slip by. I recall withdrawing from a bank, in the year 1892, the savings of several years, amounting to $1,000, and putting them into ten shares of General Electric stock. I afterwards sold the stock, at a profit of a few points, in order to obtain capital needed for my marriage and the set-up which the event called for; but apart from the reason for my action, I thought I was quite lucky to be able to get for the stock more than it had cost me. In those days, you know, frenzied finance was a sport that only millionaires participated in. A small investor was tickled by small gains."

"As a confirmed and perhaps a canny bachelor," my companion remarked, "I wonder what the value of your original investment would be to-day had you chosen to remain single and kept it!" He had previously informed me that he had never married.

"So far as the change of investment went, it seemed to me at the time a wise one," I said, "and I've remained satisfied with it. However, the curiosity of a bachelor, canny or otherwise, is valid enough, and there is no reason why it should not be gratified. The requisite information to gratify it may readily be obtained by doing a simple sum in arithmetic. In-

deed I've already done the sum, so am able to give you the result. If to the original investment of $1,000 for ten shares of stock I had added $1,250, pursuant to the exercise from time to time of rights to subscribe for additional stock, my total investment would have become $2,250. Such total investment, in the form of present General Electric stock, would have had a market value in July, 1929, of about $70,000; and apart from the enhancement of market value I, of course, would have received my share of dividends payable in cash during the thirty-seven years from 1892 to 1929. Naturally, I wish I could have kept the investment and wedded, too, but that is an academic point."

The figures given to my old-time chum relative to that purchase of stock by me in 1892 are a summary, on a small scale, of the story of General Electric as an investment. A comprehensive review of details would be easy enough to make, but will be omitted. While the points of view of Wall Street have an interest of their own, sometimes intense and always widespread, they do not pertain directly to my present purpose. This purpose is not so much to stress material values, which have been stressed quite enough, as to give values of another sort an appropriate setting and an adequate appraisal.

Thus instead of featuring the General Electric Company as an extraordinarily efficient profit-mak-

ing mechanism, I shall endeavor to show why it is such a mechanism. That is to say, I shall strive to indicate the causes of its prosperity. Success itself always is impressive, but the circumstances to which it is traceable are likely to be revealing as well as impressive.

III

Early Eighties

SUNDRY versions of the origin of the General Electric Company, fairly accurate perhaps, but casual and colorless, have from time to time been published. The version that I shall offer will probably not be much different in substance from these, and it may be no more vivid, but I expect that it will at least show a relationship of growth to origin heretofore clear to but few.

My version will start with a brief sketch of the state of the electrical art in 1882.

It was in that year that a group of Lynn, Massachusetts, shoe manufacturers journeyed to New Britain, Connecticut, to inspect a small factory which had been established there in 1880 by the American Electric Company to make dynamos and electric arc lamps. The Lynn men, among whom was Charles A. Coffin, then under 40, had, it appears, first become interested in the work of the American Electric Company as a result of investigations made by Silas A. Barton, a newsroom proprietor, concerning the illumination of the local armory. Subsequently they had purchased a controlling interest in the New Britain enterprise, and their mission in the Connecticut town was to appraise their newly

acquired property and decide what to do with it. They were practical business men, and in no sense is it disparaging to assume that money making was their primary aim.

The young corporation of which they had obtained control presently became the Thomson-Houston Electric Company. It was run under that name, with manufacturing located at Lynn, until merged, in 1892, with the Edison General Electric Company, to form what is now known as the General Electric Company.

At the period of which I write, the applications of electricity, as may readily be imagined, were crude in form and meager in extent as compared with its applications today. Yet the electrical art was not precisely in its infancy. The principles enunciated for more than a century by scores of diligent investigators, such as Franklin, Oersted, Faraday, and Maxwell, were familiar enough, at least to anyone having either a practical or theoretical interest in the subject.

Edison, as yet under 35, was famous because of the initial success of his carbon-filament incandescent lamp, constructed in 1879. The electric arc lamp developed by Charles F. Brush, flickered and sputtered in a public building or on a highway here and there, but the utility of the contraption, as it was called by the unskillful, was quite plain to the judicious, for in periods of steadiness it gave a volume of

illumination vastly greater than was supplied by the kerosene and gas lamps which it was destined soon to supplant.

The American Electric Company, too, at the New Britain factory, was manufacturing for sale an arc lamp invented by Elihu Thomson. This lamp, in its initial form, had provided illumination for a bakery in Philadelphia. The bakery in question had been chosen by Thomson as a suitable place in which to set up an electric lighting system to demonstrate the commercial value of his invention.

But I am slightly ahead of my story. The building of dynamos had, of course, preceded and been contemporaneous with the construction of lamps, incandescent and arc. In Germany, Siemens and Gramme had devised workable forms of self-exciting dynamos, and, in the United States, the labors of Brush, Edison, Thomson and other pioneers, in connection with the development of electric generating apparatus, had also been fruitful.

It was under patents granted to Thomson and one of his early coworkers, Edwin J. Houston, for dynamos, and accessories of an electric lighting system, that the American Electric Company was operated.

Many deductions, more or less interesting and significant, could be made from an analysis of conditions in that pioneering era. A discerning historian would not, however, see in the mere inception of the General Electric Company—which is here viewed

more peculiarly as an outgrowth of the American Electric Company than of any other corporate unit—any extraordinary vision such as is often loosely attributed to men who participate in the launching of a successful project. Moreover, it seems unlikely that he would see in it the outcome of any conscious desire to promote scientific, industrial, or social progress.

In short, with the exception of Coffin, who must have borne the hallmark of genius from the outset, those Lynn shoe manufacturers were poor subjects for either a hero worshipper or an anthropologist concerned with the study of exceptional human types. In the eyes of their contemporaries they were doubtless mere normal business men eager in the main, as are normal business men everywhere, and at all times, for private profit. The conjecture has already been offered that they were primarily money makers, and it may further be surmised that, as such, they saw as much opportunity to extract a penny from electricity as from leather, and seized the opportunity.

All that I am able to recall concerning one of them is a bit of his humor that struck me as corrosive. It was occasioned by mounting outlays for development. "In our zeal to test Ohm's law, or any other law," he said, "we must not forget that our stockholders are yearning for dividends."

But from what is known of Coffin's early associates it is also evident that, broadly speaking, profit through constructive effort was their objective. They were not mere commercial adventurers. Nature had endowed them with old-fashioned uprightness of character, and this went with their capital into the New Britain enterprise. The capital, it must be assumed, was essential, but of the two assets, there is no doubt that the uprightness of character was the further reaching in its effects.

IV

Birthplace of General Electric

FIXING upon New Britain as the birthplace of the General Electric Company calls for a word of explanation. As anyone familiar with its history knows, the Company is an aggregation of a dozen or a score of corporate units. It may be likened to a huge tree, the growth of which is traceable, not only to its own roots, but to a great variety of scions that from time to time have been grafted upon it.

That comparison may not apply in a literal sense to the Edison General Electric Company, for the process by which the Edison General Electric and Thomson-Houston Electric Companies were joined was rather one of amalgamation than of grafting; but such a distinction, important though it may have been accounted at one time, is of little or no concern to anyone now. That some of Edison's initial inventions were the basis of the Edison General Electric Company is well known. That the Edison General Electric Company was efficiently managed is also well known. Such facts are merely not pertinent here. The pertinent fact here is that the Lynn shoe manufacturers supplied the consolidated enterprise, the General Electric Company, with its business leadership.

Unobtrusively alert, dynamic in a noiseless way Coffin was universally recognized as prophet and lawgiver, architect and master workman, until his death in the summer of 1926.

A few months before that event, he was reviewing with me, in his office in New York, certain statistical comparisons, some of them the fruit of suggestions made by him more than a quarter of a century before. Replying to a comment of his, I said: "The statements have not been sent to you of late because of the assumption that you welcomed relief from details."

For a moment my remark seemed to amuse him; then his expression became pensive. He was 80, and had transferred to others many of the burdens which he had long borne. "Well, well," he said at length, in his hearty manner, "what a curious misunderstanding! Anyway, be sure to put my name back on the list of those to whom the tabulations are regularly sent."

I replied with conventional deference that there would be no further "misunderstanding," but this is what I thought: "How eager is this war horse of bygone days to be in the fray!"

His request, it is needless to say, was punctiliously complied with, and when it became appropriate finally to remove his name from my mailing list, the pang of regret that I experienced because the man was no more, was mingled with the rather extraneous

reflection that the statistics had lost one discriminating student and interpreter.

Coffin's understanding of figures, by the way, was one of his notable characteristics. There was wizardry in it. He seemed to be able to see at a glance the substance of a balance sheet or any statement of operations, however complex. A special pleader wishing to mislead him would have found it difficult, if not impossible, to do so through any juggling of statistics.

I shall have more to say later about Coffin, and shall also speak of others who were closely associated with him and whose work was in some respects no less effective than his. Much that is suggestive may be seen in the mere framework of an institution, and in such visible circumstances of its growth as a faithful chronicler is expected to record. Of far greater significance, however, is human leadership, that controlling and guiding force that gives to any instutition, or any cause, its tone and trend.

To be sure the General Electric Company, as it is known to-day, is far from being the work of any one man or group of men. Rather must it be viewed as a product of the coördinated efforts of many men, some of them with marked administrative capacity, others with genius for research and analysis, and others with imagination to devise, and skill to fashion, the machinery that makes electric energy an essential of daily life everywhere. Inventors particularly, one

after another, came to it from widely scattered fields other than those in which the Edison and Thomson-Houston specialists labored. Embodied in the apparatus that bears its monogram are the conceptions of Sprague, Stanley, Wood, Vandepoele, and many other equally diligent but less fertile workers.

That drawing of strength from different sources, and its utilization in a composite or fused form, may be said always to have been the quintessence of General Electric policy. "Let us accord him a welcome; we may be entertaining an angel unawares," was a favorite comment with Coffin when he brought an outsider into the family circle and sought to create an atmosphere in which he could do his best. And frequently the outsider, whether possessed of angelic traits or not, proved to be a rich acquisition.

But while many individuals came, and went, or stayed to be useful and to thrive, while old methods were replaced by new and improved ones, while company after company was acquired, each contributing whatever value was in it to the upbuilding of the parent structure, while plans of expansion were evolved and effect was given to them—throughout this process of change, adjustment, assimilation, and achievement, uninterrupted during a period of nearly fifty years, the original leadership of which I speak remained clear-cut, taut, and constructively dominant.

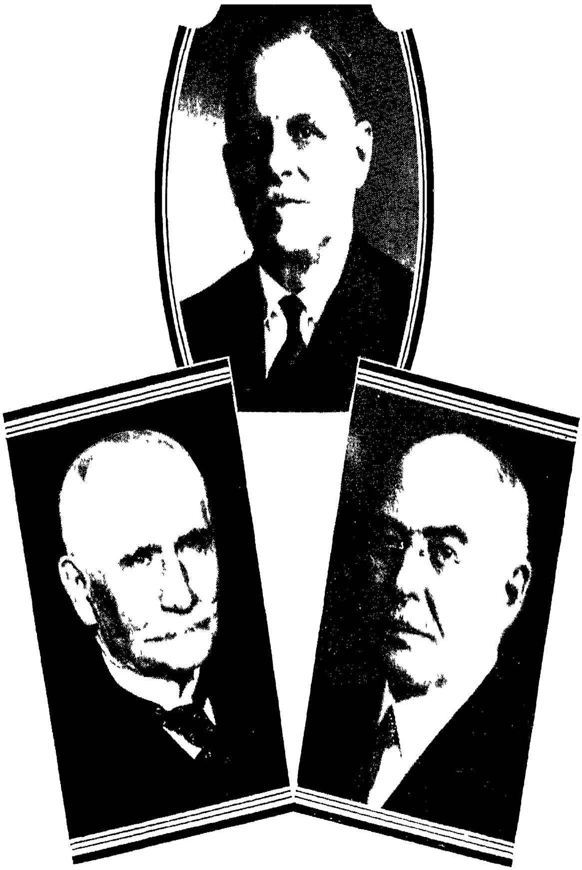
That is why the General Electric Company is traced back in a direct line to the American Electric Company which started its work in New Britain in 1880 and was subsequently acquired by a syndicate of Lynn shoe manufacturers.

None of the members of that syndicate are living, and, so far as the public is concerned, all of them, with the exception of Coffin, are virtually forgotten. What is impressive is their historical importance as a group. From them, as business men, as well as from Thomson, and a youth who accompanied him to New Britain as an assistant, and who will be referred to in succeeding pages, came the character which has given the institution of which I write its peculiar effectiveness.

V

The Three Fathers

AMONG the men associated with the Thomson-Houston Electric Company from the time it was established at Lynn to the formation of the General Electric Company in 1892, were three who were conspicuously active. They may or may not have been the ablest of the group. That point calls for no analysis here. It is the influence that they exerted, through what they did and what they were, that appears significant. Two of them, Thomson, physicist, fertile inventor, and one of the foremost living men of science, and Coffin, financial and commercial organizer and manager, have already been mentioned. The third was Edwin Wilbur Rice, Jr., like Thomson a keen student of electrical phenomena and applications, but younger and with less experience. He had been a pupil in the Boys' Central High School of Philadelphia when Thomson was a teacher of physics and chemistry there. Though scarcely more than 20, he had displayed unusual executive ability as Thomson's assistant at the New Britain factory. "My first job at New Britain," he said later, "was to give the office a coat of whitewash, which it was sadly in need of." No doubt the budding administrator was greatly impressed with the necessity of that particular task,



THE THREE FATHERS

ELIHU THOMSON
CHARLES A COFFIN E WILBUR RICE, JR

but it is a fact worthy of note that whitewashing was never thereafter viewed by him with favor when evidence of the operation appeared in reports from his lieutenants. Once when, as a member of his staff, I must have been trying in dilettante fashion to sidestep some doleful facts, he said, "Let's know what the worst is; then we can seek for the best." After the transfer of manufacturing from New Britain to Lynn, he was appointed factory superintendent and consulting electrical engineer there, and a record of his administrative and engineering activities thenceforward for more than thirty years is an integral part of industrial history in the electrical field during that period.

Reference has been made to the old-fashioned uprightness of character which the Lynn shoe manufacturers contributed to the enterprise. Thomson and Rice, both of whom had had the advantage in early life of favorable home influence, knew no other rule of conduct than that which is based upon strict integrity, so that their union with Coffin was altogether natural and congenial.

Though an astute trader, then, as later when his trades were with financial giants, Coffin imparted a high moral tone to negotiations with customers and to transactions of all kinds. Thomson and Rice gave a similar tone to claims made as to the quality and performance of the apparatus which was designed by them and offered for sale. They had faith that great

things could be done with electricity, but when drawing attention to the merit of their wares, scrupulously avoided over-statement.

All three men, though intensely earnest, were in fact singularly unassuming. They lacked both the virtues and the defects of the typical go-getter of to-day, with his faith pinned to the paraphernalia of high-pressure salesmanship. With Babbitt, Don Quixote of modern business, made familiar through the genius of Sinclair Lewis, they had absolutely no mental or spiritual kinship.

Experimentalist from instinct and habit, and with some of the attributes of a philosopher, Thomson found laboratory pursuits and study more congenial than activities of a routine and administrative nature, and was, therefore, quite content that his two associates, whom he implicitly trusted, should serve as protagonists and spokesmen. He had plenty of native shrewdness, but for the most part exercised it as a consultant. He served as a director of the Thomson-Houston Electric Company, and his counsel in that capacity was highly valued.

The working arrangement of the trio, not fashioned after any organization formula, but rather evolved to suit their temperaments and inclinations, continued for nearly a decade. Meanwhile the Thomson-Houston Company grew and prospered. To its early dynamos and arc lamps, redesigned and improved, were added power generators and motors, incandes-

cent lamps, and sundry regulating, controlling, and protective devices. Such new factory buildings as it needed from year to year, in order to supply the increasing demand for its products, were erected and equipped with tools. The number of its employees increased from 40 to 4000. The value of its stock rose on the Boston Stock Exchange from $25 to $300 or more a share. The inhabitants of the most conservative corner of the continent were stirred, as they had never before been stirred, by accounts of the amazing things done, and possible of accomplishment, with the subtle force that Franklin had drawn from the clouds by means of a kite, and Galvani had found in a frog's leg. And, as one thinks of those days, it seems appropriate to observe that Thomson, the wizard, and his coworkers and disciples were lucky that they were living as men, in Lynn, in the nineteenth century, and not as women, in nearby Salem, at an earlier period.

Thomson, Coffin, Rice—those are the names of the men whom it seems fit to designate as the fathers of the General Electric Company. To be sure they were at all times surrounded by able and brilliant colleagues and assistants, who performed useful service as directors, managers, and technical experts. But the processions of individual workers that I am able to recall are not of primary concern here. My thoughts for the nonce are centered upon those three pioneers. They, too, were able individual workers,

but they were more: as they worked they set up business ideals; and it was because of the particular ideals set up by them that the General Electric Company blazed the trails and wrought the wonders with which its name is associated.

Acceptance of that view will not be difficult for anyone to whom the purpose of these sketches is evident. I am not merely setting down facts. I am writing of the spirit of a great corporation as one might write of any institution that survives for a long time, and whose work, woven into the fabric of society, is enduring—enduring because it has a spirit and is not merely a mechanism.

And the spirit of the General Electric Company is worth writing of, and worth understanding. It is of greater consequence than its achievements, notable as these have been. Without it the achievements would have been impossible.

Thomson, Coffin, and Rice were the creators of that spirit, or rather the spirit radiated in a noticeable degree from them. They were not prone to speak of it and seemed content that it should be shown in the things they did or the ways in which they did them. But its effect upon others was that of a contagion. Anyone who came within the range of its influence quickly caught it and was thenceforward a General Electric booster, whether he designed, produced, or sold electrical equipment, or purchased it.

As I have already said, one of the three fathers of the General Electric Company is gone. The others are living and active. Of the one who is gone, his fellow directors speaking of him and of the institution with which his name is linked, said: "His spirit was its inspiration. He had unfaltering courage in trying times. He had modesty and self-restraint in the days of great success."

Technicians sometimes wonder if the General Electric spirit can be preserved as a working asset by tracing it, with the aid of a chart of some sort, to the particular form of organization under which it has been fostered most, and standardizing that form. The answer is that charting is always feasible, but that in this case the clues that it would give would probably lead one far afield. Although some forms of organization may have been more in harmony with it than others, the spirit of Thomson, Coffin, and Rice has been kept alive under different forms, and, at times, apparently without much dependence upon any form. As the story of the Company is unfolded, forms of organization, systems, and procedures will, however, naturally be dealt with on their merits, possibly with some degree of satisfaction to those who think best with the aid of charts and quantitative data. I wish, of course, to be intelligible to technicians, for our age is a technical one.

VI

A Serious Jolt; Panic of 1893

THE GENERAL ELECTRIC COMPANY, as a commercial enterprise, received the only serious jolt of its career in the middle of 1893. It was more than a jolt; it was nearly a catastrophe. The brink of a receivership was reached, but solvency was maintained through the desperate expedient of selling for cash a large quantity of assets at a third of their face value.

The business of the Edison General Electric Company, like that of the Thomson-Houston Electric Company, had grown rapidly up to the time that the two units were consolidated, in 1892, and expansion continued for a year thereafter, until the total number of employees in the manufacturing establishments at Schenectady, N. Y., Lynn, Mass., and Harrison, N. J., reached 8000. By that time the railway motor had become an outstanding item in the list of General Electric products, many of the street railway lines of the country having discarded the horse for the trolley.

Then came the crash. The financial panic, starting in the spring, continued with unabated fury till September. It called for drastic, country-wide retrenchment, which in turn was followed by a trade

reaction so severe and extensive as to amount to a partial industrial paralysis.

The General Electric Company was hit hard. Orders for its products shrank seventy-five per cent. Of its 8000 employees, 5000 had to be laid off, and there was not enough work to keep the remaining 3000 occupied full time. A portrayal of the conditions in detail would make a sombre story; they were distressing in the extreme; and a dark outlook made them hard to cope with.

The assets which were sold in order to obtain cash with which to meet obligations comprised stocks and bonds which had been taken by Coffin, in payment of accounts of local companies, to promote the introduction of electric light and power, and, in turn, the sale of electric equipment. The fact that these securities were surrendered at a seemingly heavy sacrifice occasioned more or less adverse comment at the time, particularly as they were purchased by some of the larger stockholders. Subsequently, however, it was recognized that they could not have been disposed of on the market for even a third of their face value. With the general gloom and lack of confidence that prevailed, there was little or no demand for securities outside of those in the gilt-edge class. Coin of the realm was what people wanted, and it commanded a premium. There was more or less discrimination even against bank notes tendered in settlement of debts Some creditors

were finicky enough to require government certificates payable in gold.

Coffin's sensations after the panic were like those of a commander whose ship has reached port after having encountered a terrific storm and been dangerously near the rocks. His experience had been a nerve-racking one and he never forgot it. Its effect upon his judgment was permanent. With economic conditions normal, as of course they were during the greater part of his career, he was enterprising and sanguine to an extraordinary degree, but with the passing of the years, and despite the steady growth of the electrical industry, he could not avoid seeing in every passing cloud upon the business horizon the terrors of 1893. Keeping the General Electric Company as remote as possible from danger of any sort became a penchant with him. At times he exhibited an excess of caution that disconcerted his associates. The power to envisage opportunities for growth was his in a marked degree, but occasionally a programme of expansion that seemed to others highly promising had from him but lukewarm support.

His attitude toward men, too, was uneven, not to say erratic. Those who enjoyed his confidence saw in him nothing but kindliness, patience, and princely charm. Toward others he could be cold and obdurate if they had dealings with him, distant and inscrutable if they had none.

That much needs to be said of Coffin by anyone aiming faithfully to portray him. But it takes nothing from his stature. He was an able and a wise industrial leader; an amazingly successful one, too. Without his caution, upon some occasions, in the use of capital for new ventures, and without his knack of holding at arm's length anyone whom he had cause to mistrust, the General Electric Company would not have been kept continuously impregnable, and thus able to fulfill its mission.

It is the custom of financial writers, when discussing the affairs of the General Electric Company, to stress the conservatism with which its assets have been valued. That conservatism was a consequence of the panic of 1893, during which a spade was called a spade, and little or no recognition was given to contingent or potential values of any kind. Having kept the enterprise of which he was chief steward from being totally wrecked, Coffin resolved to make it invulnerable, so far as this was humanly possible, under any conditions of an adverse character which it was likely thenceforward to encounter.

"We had a close shave," he reflected when the first effects of the financial storm were over. "We were headed for the poorhouse, and the prospect was anything but pleasant. Hereafter we shall cherish no illusions. Our aim, as we strive for expansion, shall be to build up plenty of reserve strength and to maintain it."

The work of building up "reserve strength" was tackled without delay and carried on in thoroughgoing fashion. Sound assets were catalogued at bargain counter appraisals and allowances set up for possible future shrinkages of every description; provision was made for the closest scrutiny of credits; a strict censorship of disbursements was established; plans were laid to insure at all times a liberal cash balance; and, as a climax, the basis of earnings was contracted through a scaling down of capitalization to the extent of forty per cent.

At the time of which I write, Coffin, by the way, coined an expression which is now widely employed by accountants and tax experts as a formula for safe and sane merchandise inventory valuations. Asked to indicate how such valuations should be determined he said, "Use cost or market value, whichever is the lower."

Such measures as those described, though an outcome of an acute situation, were not merely temporary expedients. So far as the General Electric Company was concerned they became an integral part of a settled policy. To be sure, a stock dividend of thirty per cent was distributed in 1912, but it was amply warranted by accumulated visible surplus, and was stated to be "for the purpose of recouping the stockholders in part for dividends passed or reduced during the years 1893 to 1902." Other stock dividends came later, but they, too, represented but

fractions of profit that flowed continuously into the business, the other fractions consisting of "reserve strength" in one form or another. Ultra-conservatism of capitalization remained a creed with Coffin as long as he lived.

That creed eventually became a more or less outworn one, but it had had its day and, on the whole, had served a useful purpose. Whether the doctrine which seems to have replaced it, in the minds of industrial leaders generally, and which presupposes a capital basis so flexible that it is scarcely a basis at all, will serve a more useful purpose, remains to be seen. The so-called splitting-up process, now a feature of many corporate programs, is thought by some to be one of the causes of the recent orgy of speculation, and in some respects that view is plausible. Share trading is certainly stimulated by the greatly increased number of shares made available through split-ups.

So far as the long-range consequences of the splitting-up process go, however, they may prove to be wholly beneficent. The capital structures of the leading corporations of Coffin's day, while safe, were not without economic drawbacks. Perhaps they had too large a measure of safety.

VII

A HUMAN ASSET SALVAGED: STEINMETZ

ONE incident of the panic of 1893, of which my recollection is vivid, and which has not heretofore been related, may have special historical interest. While retrenchment was under way at all offices and manufacturing plants, the directors of the General Electric Company called upon each division head to submit to them, for critical scrutiny, a list of salaried employees in his division; the name of each employee to be followed by the amount of his compensation, an outline of his duties, and a statement of the conditions under which his services could be dispensed with, or his salary reduced.

Pursuant to that requirement, Rice, as head of the engineering and manufacturing division, compiled a list of engineers, department heads, clerks, and foremen. Conditions, varying of course in character, under which their services could be dispensed with, or their salaries reduced, were specified for all of these employees save one who had been in the service a relatively short time. I cannot remember the precise language of the comment made relating to that one employee, but here is its substance:

"Charles P. Steinmetz; electrical engineer; no conditions; services indispensable; increased compensation warranted."

Steinmetz at the time was a young man; he had not as yet done any of the work upon which his fame rests, and none of the men who ranked with him, and among whom he labored, thought of him as possessing any extraordinary capacity. That official appraisal, therefore, was not only prophetic, but, in view of the conditions existing at the time it was made, had behind it a certain moral courage, which was not a common feature of industrial management then, and is not now.

Such courage, displayed in a calm, matter-of-fact, unostentatious way, always has been a part of the spirit of the General Electric Company. Without it, while Steinmetz's genius would doubtless have had fruition in some environment, and in some form, he would not have emerged from the turmoil and travail of that trying period to do the particular things that he did. From the point of view of a mere economist, there was then certainly no logical place on the payroll of a crippled corporation for the kind of service that he was qualified to render.

I recall many incidents in the life of Steinmetz, but this is not the place for them. I shall give but one or two more and then go on with my narrative. When the events of 1893 had become indistinct, like

the half-remembered figments of a frightful dream, and he was busy with those calculations that served as the basis of his great treatise on the alternating current, an associate suggested that he apply for an increase of salary.

"Why should I do that?" said Steinmetz. "My income is now more than my expenditures."

That naïve reply to a friendly suggestion was illustrative of a gift possessed by Steinmetz in a marked degree—the gift of imparting lucidity and weight to the intrinsic importance of a thing while minimizing its merely conventional importance. It was this gift that gave to some of his utterances a ring that made them memorable.

The gift of course was nothing more than a logical projection of thought from an uncommon point of view. A raise of salary may have been quite in order in his case at the time, and it would doubtless have been acceptable, but for him it was without intrinsic importance. His primary interest lay in the work he was doing, and, for the time being at least, he was content with enough salary to enable him to do the work. To take steps upon his own initiative to get the salary boosted probably seemed to him one form of wasted energy.

His quoted comment, moreover, was not traceable to any false modesty, or any unsophistication, either. Nothing is more erroneous than the assumption,

common before the death of Steinmetz and since, that his attitude toward practical problems was that of a child. To be sure, he often wilfully side-stepped practical problems, with more or less embarrassment to his friends and well-wishers, but he was a resourceful and a clever trader when trading was a means to an end that seemed to him intrinsically important.

There comes to my mind the case of one of his assistants for whom he wanted increased compensation. The man apparently had some adventitious value for Steinmetz, but his inherent value seemed to others limited. While reviewing with Rice a schedule of subjects requiring his attention, I remarked that Steinmetz wished to discuss with him the case in question and obtain action thereon.

"Oh," said Rice, in a tone of resignation, "put the increase through without further ado. Steinmetz would be sure to persuade me of its justification; his logic is irresistible; so the time a discussion would take may as well be saved. But ask him to step in at his leisure. I want him to tell me how we can get out of this turbine trouble in Chicago."

In the conference that followed, nothing was said about that assistant, or of the raise of salary that was granted to him with reluctance, for I had hinted to Steinmetz that the case would not be hurt any by silence, and might be by argument; but a cure was found for the turbine trouble in Chicago.

So far as appreciation of the value of money goes, Steinmetz showed in many ways that he did not lack it. Anyone who ever had the privilege of participating with him in America's greatest indoor sport, knows that poker, even, has no turn or twist that he could not, in practice, quickly understand and evaluate. On one occasion he held four aces against an equal number of deuces which had come to another player, and the subsequent proceedings were so adroitly managed by him that the players not immediately concerned had opportunity to take naps before the holder of the quartet of deuces began to doubt the value initially placed upon his asset.

"One should be more conservative with only four deuces," Steinmetz cackled as the competing hands were exposed.

There is a vast difference between a profound student of electrical phenomena and a skillful poker player; but Steinmetz was both. In fact, the versatality of the man was sometimes amazing. I recall another occasion on which he went to a banquet, and, in the absence of the individual who had been chosen to act as toastmaster, filled that difficult job in as tactful and clever a fashion as I have ever known it to be filled by anyone. In only one respect did he fail to run true to banquet form. He wore a sweater in place of a tuxedo.

Giving this much space here to Steinmetz is scarcely inappropriate. He was peculiarly a product of the

General Electric Company, and it was through him, with his magnetic personality and gift of expression, that its spirit first became widely familiar. Moreover, the fact that he was one of the human assets salvaged from the wreckage of 1893 is worth recording.

He will inevitably reappear in this history.

VIII

THE COFFIN POLICY

THE sale of those stocks and bonds, after the panic of 1893, at a third of their face value, was looked upon at the time as a major operation. In retrospect its appearance is that of a pin prick. The total shrinkage amounted to about $8,000,000, a trifling sum compared to the market value of the General Electric Company reached in July, 1929, of approximately $2,800,000,000.

For a student of history, however, the assets in question have special significance, apart from their fate. They were one of the early signs of the application of a policy through which the growth of the electrical industry was accelerated.

That policy consisted of the employment of capital by a manufacturing enterprise, not only for normal manufacturing purposes, but to extend existing markets and create new ones Coffin always was essentially a builder, never an exploiter. Had literature or religion been his chosen field he would have been a poet or founder of a sect rather than a critic or cleric. Under his leadership the Thomson-Houston Electric Company, and later the General Electric Company, "dipped into the future far as human eye could see" and staked their capital on "the wonders that would

be." In prosaic language, they invested money in electric equipment in exchange for stocks, bonds, and notes of companies organized to supply electric energy to communities whose inhabitants for the most part could then see no use for the energy save as a luxury for the very rich.

As the facts recited in the previous chapter indicate, much of the money thus invested previous to 1893 was lost, but that was clearly enough seen to be due to a widespread industrial upheaval, in which values of all kinds were either destroyed or seriously impaired. Coffin still thought his policy fundamentally sound, and it was not abandoned. Instead its form of application was improved through an extension of technique which included safeguards suggested by experience.

As early as 1890 the Thomson-Houston Electric Company had organized a self-contained corporate unit, the United Electric Securities Company, through which, from time to time, securities taken from local companies, in part payment of equipment, were marketed. In 1894 the General Electric Company created the Electrical Securities Corporation to serve a similar purpose on a larger scale. The local operating companies thus continued to receive needed financial assistance effectively to fulfill their mission, while the General Electric Company exercised its functions as an engineering and manufacturing concern largely unhampered by the practice of taking

securities directly in exchange for equipment. Some of the more conservative stockholders had always been prone to view this practice as hazardous. "It leads to entangling alliances," one of them argued. "Our job is to manufacture and sell electrical equipment. A wise cobbler sticks to his last, and a corporation ought not to be less wise than a cobbler."

Of course the weakness of that argument lay in the provincialism which it implied. It had little appeal for Coffin, whose outlook was cosmopolitan, but it influenced him in the development of procedure.

The United Electric Securities Company and the Electrical Securities Corporation served for a time the purpose for which they were created. The kind of work which they had done was, however, eventually taken up by the Electric Bond and Share Company. It was through the Electric Bond and Share Company, incorporated in 1905, that the Coffin policy of extending the use of electricity was to have its fullest application. That corporation, now a gigantic holding unit, separate from the General Electric Company, besides insuring an adequate supply of capital for the local companies by making their securities marketable, became their guide, philosopher, and friend. Some of them it helped to organize, and during the initial stages of operation, to manage. Into others that languished, it instilled new life by pointing out opportunities alike for increased efficiency and for profitable expansion. It recommended

advantageous mergers, and employed its facilities to bring them about. Its activities, in a word, followed a comprehensive scheme of helpfulness. Operating experts and trained engineers, rather than professional promoters, were delegated to carry out its programs, and, therefore, the results which it accomplished were of a substantial and enduring character.

To ascribe philanthropic motives to the Electric Bond and Share Company would, of course, be altogether foolish. The service which it rendered was undoubtedly well paid for. Fees avowedly were collected for its planning and supervisory work as well as for the advice which it furnished. It must have been enriched, too, through appreciation of the value of junior securities which came into its possession either as payment for service or upon favorable terms.

All that, of course, is quite in accord with normal business procedure. Little comfort is to be found in it by a chronic critic of public utility corporations. To give as well as to receive is at least much better than to receive without giving, and there seems to be no doubt that, in its upbuilding of public utility enterprises, the Electric Bond and Share Company was a giver as well as a receiver. A corporation, like an individual, may receive more than it gives, but that is not usually classed as a fault.

The suspicion, lately voiced in rather explicit fashion, of something unlawful, or at least inimical

to social welfare, in the public utility structure reared in a large measure by the Electric Bond and Share Company, prompts a word of comment here, a word in which, it is hoped, there will be no bias.

Success on a huge scale often leads to suspicion of crookedness, and as a consequence we always have with us official investigations of one kind or another. These investigations in themselves are inevitably expensive to the public, but need not be frowned upon on that account. The major objection to them is that for the most part they are futile. Conscious violation of law in the conduct of industry is exceedingly rare, and is classed as stupid, even by those assumed to be guilty of it; hence effort to prove it is in most cases wasted effort.

The public utility situation appears to call for synthesis, so that it may be seen as a whole, and with reference to the good of society. Economists favor unification of facilities, in itself, to reduce the cost of power and make it increasingly available, but their minds do not meet as to the form which the unification should take. Since, however, forms are in the last analysis determinable by society, it may safely be assumed that unification will ultimately take the form best suited to it. Should an extension of government control, or even out-and-out government ownership, be wanted, it could readily be had, since popular will, expressed through established procedure, is law. In any event there seems

to be no reason why the securing of economic advantages should be delayed until full agreement as to the distribution of the advantages can be reached. Economy is a primary virtue, with a status more or less detached, and nothing is to be gained by a dog-in-the-manger attitude toward it.

I recall a talk that I once had with a lawyer concerning investigations of the so-called Power Trust. He was a corporation attorney prone to give his own thoughts a free run when he could do so without departure from good taste.

"If the investigations could be carried on for purposes other than that of finding indictable offenses," he said, "some good would probably come from them. It may be, for example, that the volume of public utility securities has become so vast that normal earnings thereon are incompatible with reasonable rates for service. If that is so, it suggests regulation within the law rather than inquisitorial procedure and attempted prosecution under it. Levying of tribute upon the public, through mere pyramiding of capitalization, that is, multiplication of shares of stock, is readily preventable through exercise of the rate-setting function, which is already a governmental function. Perhaps that function has not been skillfully exercised. An investigation of the point might be as futile as many other investigations, but it would be at least logical, and could not impede normal unification, with the economic advantages that go with

it, as investigations with indistinct or oblique aims are bound to do."

Any extended discussion of the public utility system, or of the problems related to it, would, however, be out of place here. The purposes and procedures of the Electric Bond and Share Company have been briefly sketched only because they were linked to the Coffin policy, to which the growth of the General Electric Company is traceable. Moreover, my experience has been remote from the public utility field, and first-hand information is needed in order to write illuminatingly about any subject.

Of one thing I am certain. Coffin had no sympathy with any of the restrictive features of monopoly. During the many years that I saw him in action, or felt his influence, as an organizer and administrator, his aim, on the contrary, was to foster initiative and stimulate growth. He favored the pooling from time to time of corporate interests, but less for the immediate economic gain that it promised, so far as any particular group was concerned, than to secure concert of effort in developing the electrical art and applying the art to the world's work.

Was money making his motive? To be sure it was, but he was also actuated by other motives. In an age such as ours, in which money making is the most completely standardized as well as the most widely rational pursuit, a man is bound to be a money maker, in theory if not in practice, unless he is con-

tent to be a lonely member of society, and in some respects a superfluous one. Of course, there are sordid money makers, as there are sordid college professors and even sordid clergymen, but the most successful ones, if they do not hitch their wagons to stars, at least try to keep them out of the mire. In fact, the effort to make money—constructively I mean, not by betting on race horses or forestalling the stock ticker—goes hand in hand with most of the major virtues. Such effort consists in part of the exercise of foresight, frugality, prudence, patience, and self-control. Also, its effect is not necessarily to make one ruthless or indifferent to the rights of others. On the contrary, it tends to develop a sense of social decency in those who have little or none to begin with. Often it is associated with, and is stimulated by, the tenderest sentiments. "I loved my wife and children," said a wealthy acquaintance when I asked him how he had built up his estate. "To be sure, there was nothing novel in that, for most men are devoted to their families; but I trace to it my passion for money making. Energy and luck were, of course, factors of my success, but, I think, collateral or consequential ones."

Coffin was a money maker of a high type, high according to criterions commonly employed in appraising money makers. He was shrewd and thrifty, and at least able to simulate craft when he had to

cope with it in others, but no trace of the predatory instinct was discernible in his conduct.

Nor did he seek pecuniary gain in solitary fashion. For every dollar that he made for himself, through what he did, many thousands were made, and continue to be made, by others. Investors had faith in him, and their faith has been richly rewarded. Moreover, countless numbers of men and women have been provided with lucrative employment as a result of his initiative and enterprise.

So far as his own acquisitions went, the estate that he left, $5,000,000 or $6,000,000, I believe, was generally thought to be moderate in view of the unsurpassed opportunities that he had, as a pioneer in a highly profitable industry, to accumulate one of the gigantic fortunes such as are now so common.

Of much greater value than his skill as a money maker, however, was the contribution which he made to the world's progress in extending the use of electric energy. It is for that contribution and, above all, for the influence which he exerted to give a high tone to big business, when big business was handicapped more by buccaneers and highbinders than it is now, that he is likely to be long remembered, and deserves to be.

COMMERCIAL LEADERS

EUGENE GRIFFIN

JESSE R LOVEJOY BERNARD E SUNNY

IX

Commercial Ethics

THE Coffin policy of promoting growth through helpfulness was automatically extended to the day-by-day work of selling electric equipment, not only to the operating companies who, other things being equal, were more or less morally obligated to buy it, but to all classes of purchasers. The salesmen of the General Electric Company, such of them at least as kept their jobs very long, were governed by a code of ethics in which chicanery, subterfuge, or even cant of the garden variety had no place.

Eugene Griffin, for many years head of the commercial division, strove for "open covenants, openly arrived at" with as much zeal as he strove for an order. Once he was reviewing a pending transaction the terms of which seemed vague, though, under any interpretation, favorable to the vendor. "A contract," he said, "ought to be so drawn that it will not only be understood, but cannot be misunderstood. That may be a distinction without a difference, but the distinction is important. The idea that I want to convey is that whatever may be the legal status of a deal, clear mutual understanding of its terms, and mutual satisfaction with them, are essential in order to make the deal morally valid."

The General Electric code of ethics was developed to such an extent as explicitly to call for a considerate attitude toward competing manufacturers. Addressing an annual assemblage of selling agents, Griffin said, "Our product must be sold on its merit, not on the demerit of any other product " Upon another occasion, while emphasizing the folly of misrepresentation in business negotiations, including remarks of a misleading nature about a rival's product, he gave a striking definition of a lie. "A lie," he declared, " is not merely a false statement; it is also a statement which, though true, is made with intent to deceive."

I am not writing biography, but no historical sketch of the General Electric Company would be complete without at least a few words about Griffin's personality. He was what would nowadays be called a super-salesman, not because of his ability, which was exceptional, but because of his sterling manhood, because anyone having intercourse with the man found him genuine, frank, decent, and helpful. It was habitual with him to go out of his way to insure a square deal for a customer or an employee.

A graduate of West Point, Griffin was a good example of a soldier, who, with some of a soldier's pomp and pride, wished above all to be human, and knew how to be. His military training was unwittingly reflected in his methods. A stricter disciplinarian the General Electric Company never has

had. Ringing reprimands that made offenders wince came from him for indifferent or slovenly work. But they left no scars. No one ever doubted his sincerity and good will.

The manager of a remote district office once said of him, "He is trusted and loved by every salesman on the circuit," and after his premature death in 1907, Coffin spoke feelingly of the lasting effect that his memory would have.

Not only is the lasting effect of Griffin's memory now manifest, but his judgment finds continuous expression in many procedures developed and introduced by him, and in force to-day in the far-flung commercial organization whose groundwork he laid.

I said a moment ago that I was not writing biography, but a few brief paragraphs have been devoted to Griffin, and one cannot dwell upon the character and work of that one-time influential official without thinking of his successor, Jesse R. Lovejoy. Throughout his administration of more than twenty years Lovejoy, too, applied the Coffin policy and diffused the Coffin spirit, which was the General Electric spirit. In some respects he was unlike the other pioneer workers mentioned in this narrative, but he had their modesty and engaging candor, their singleness of purpose, and their capacity for sustained hard work

A member of his staff once remarked that Lovejoy possessed the major qualifications of a commercial

leader, but was sometimes overlooked by the crowd because unschooled in the art of personal advertising. It is true that his manner was retiring. Even when it seemed fitting for him to be in the forefront of a picture, he took the background from choice. Yet no one ever thought him deficient in energy. There was merely a notable lack of ostentation in his energy. Moreover, the friendly contacts that he established were manifold, and a lively sense of human values was part of the constructive salesmanship through which he helped to advance the electrical art.

The commercial organization of the General Electric Company under the leadership of Griffin and Lovejoy consisted of a half-dozen major departments, each of them with as many sub-departments. The field was roughly divided according to classes of equipment—turbines and generators, motors, transformers, switchgear, and so on. Some overlapping was inevitable on account of the functional interrelation of equipment; but there was hearty coöperation among the members of the selling force. Coöperation was in fact logical and inevitable in the scheme of things. A salesman was expected to make the most of his job, but his value was determined not alone by his individual sales, which in the nature of the case were partly adventitious, but in addition by the influence which he exerted to increase the total sales. In one word, he was a member of a corporate

family, and his status, as such, was maintained only through the kind of effort that promoted family welfare.

Griffin and Lovejoy excelled as salesmen; but they were more than salesmen. The service that they gave to the General Electric Company was of a distinctively educational character. They humanized salesmanship, and thus developed salesmen of a high type. From their point of view, a sales contract was an equitable exchange of benefits; for they visualized the science of selling as a branch of social science. Nothing in their administrative procedures, or in their points of view, harmonized with the law of the jungle applied in any form, and on that account they inspired confidence in customers and loyalty in the men whom they trained for the work of marketing electrical products.

It is difficult to leave such a theme as that of commercial ethics without mentioning another leader who had Coffin's confidence in a marked degree and who, like Lovejoy, is still living. He is listed in the reference books as Bernard E. Sunny, public-spirited citizen of Chicago. Sunny's reputation for business acumen and reliability, in Chicago and elsewhere, is analagous to that of Marshall Field in the closing decades of the last century.

During the period of Coffin's constructive activity he served as Western manager of the General Electric Company and gave éclat to the job. His under-

standing of human relations was quite as thorough as his understanding of business procedure. He was intuitive, sympathetic, urbane, a keen student of men and of their multitudinous affairs, and a tireless worker.

Sunny did much in the early days to extend the use of electric energy. And he did something else quite as noteworthy. He made the General Electric spirit familiar in the Middle West, and, through contact with other leaders, helped to make it familiar throughout the country. It is chiefly because one reviewing the past is able thus to speak of him that he appears in this history.

I regret that there is not space to tell of many others who, while promoting the sale of its products, spread the spirit of the General Electric Company. Notable among them, if less gregarious than Sunny, were Charles B. Davis in New England, and Thomas Addison on the Pacific Coast.

Also, descriptions of the work of such men as Oscar T. Crosby, S. Dana Greene, James R. McKee, and William J. Clark would be essential in any rounded-out review of the early commercial activities of the General Electric Company.

X

Picturesque Characters

A NUMBER of able men other than the commercial and technical leaders whose work has been or will be described, rendered service of conspicuous value to the General Electric Company before its fame was established. Two of them, Joseph P. Ord and Hinsdill Parsons, as specialists, helped Coffin to give effect to his program of rehabilitation after the panic of 1893, and on that account call for notice.

Ord did his best work as comptroller, but accomplished more through effort exerted in detached, odd, and unexpected ways, than through any novel application of accounting principles. Despite the title that he bore, knowledge of accounting was not, in fact, his strong suit. He had a simple gospel, the gospel of frugality and economy of management, which he expounded persuasively, in part because his preachments were enlivened by a sense of humor. Many of his epigrams were long remembered, and some of them are still quoted. Though his heart was by no means hard, when dealing with matters of business routine he could be practical to the point of ruthlessness so far as human beings were concerned. "What's his market value?" was usually

the first question he asked when an application for increase of salary came to him for action. And his favorite dictum for any form of discontent, whatever its cause, was "Fire the kickers!" But his bark always was worse than his bite. He was fair-minded, and conscientious work never failed to receive from him ample recognition.

Incidentally Ord's abiding faith in the General Electric Company made him a liberal purchaser of its stock when the stock could be had for a song, when reputable judges gave it a status but little more favorable than that which is ordinarily given to wildcat mining stocks.

The arduous work of retrenchment for which he was peculiarly fitted was virtually finished by the year 1902, so he resigned the office of vice-president, to which he had been elected after serving for several years as comptroller, the reason dryly assigned by him for the action being that his salary was "one item of corporate extravagance." Membership in the firm of J. P. Morgan & Company was then given to him, but that, too, he soon relinquished. The atmosphere of a banking establishment was unsuited to so critical and restless a type of mind as his.

Parsons, a brainy lawyer, became an expert on contractual relations, and as such made himself immensely useful. As was the case with Ord, the ideas of business procedure found in textbooks

had but little appeal for him. His effectiveness as a leader was due in part to indefatigable energy and an engaging manner, and in part to strong backing from Coffin, who, other things being equal, seemed partial toward men of legal training.

Neither Ord nor Parsons precisely typified the spirit of the General Electric Company, but both men worked well under its influence, and for a time ranked as stars. They were picturesque characters who made worthwhile contributions to General Electric history.

XI

Samuel Insull

SUNDRY names have thus far been mentioned, but the fact is that so far as names go, this work is likely to seem faulty because of its omissions.

All that can be said, in explanation of whatever omissions may be noted, is that the work is mainly a narrative based upon first-hand knowledge. The men of whom it speaks at length were men with whom, at one time or another, I had direct contact, although incidentally they were, for the most part, the men longest identified with the growth of the institution which is my theme.

"Wouldn't an account of the work of Samuel Insull, as Edison's executive, be eminently fitting in any General Electric saga?" asked one old-timer with whom I discussed the scope of my work.

"To be sure it would be," I replied, "but I was not personally familiar with Insull's work, and, were I to write of it in detail, would be obliged to do so from hearsay, and, therefore, probably would fail in some respects to do justice to the subject."

Samuel Insull must, indeed, have been a man of great force and influence when the electrical manufacturing industry was in its struggling stage and needed strong men. He withdrew from the service

SAMUEL INSULL

of the General Electric Company in 1892 to win the country-wide fame in the public utility field which he now enjoys. A catalogue of achievements upon which that fame is based would be an essential part of any record of the commercial application of electricity during the past forty years.

All the information that came to me from time to time concerning his work prior to 1892, from those who had been associated with him, was favorable. I often heard him referred to as the administrative genius of the Edison General Electric Company, the man who had built up the Edison branch of the industry.

President Charles A. Richmond of Union College in conferring upon Insull, in 1917, the degree of Doctor of Science, described him thus: "Organizer and administrator; successful in establishing in this city a vast industry; pioneer in applying to common and convenient use the science of electricity."

Insull lived for a year or two in Schenectady, now the official home of the General Electric Company, and those who knew him socially there hold him in high esteem.

XII

FACTORY SYSTEM: RICE

WHILE Coffin, with the aid of Griffin, Lovejoy, and others was building up the financial and commercial side of the General Electric Company, Rice was doing the same thing with the manufacturing and engineering side. Rice's manner in the early days was less suave, at least from forethought, than Coffin's. To strangers he seemed grave, and those with axes to grind, particularly if they also had an excess of assurance, found him more or less unapproachable. But with sweep of imagination and rare analytical power, he had a fine innate sense of justice that made his leadership seem valid apart from the authority that went with it. For years employees of all classes, in their intercourse with one another, and in their efforts to earn promotion through service, were governed more by what became known as the Rice sense of justice than by rules, rituals, or precedents. In fact, rules were at times looked upon as a necessary evil, and there were few rigid ones. Smoking, for example, was prohibited in specified areas, and at specified times, but mainly because of danger of fire. The Steinmetz ultimatum on the question of smoking, "No smoking, no Steinmetz!" though it made a good

enough newspaper story for a generation, was wholly fictional. Steinmetz had independence of character, but was too sane to exhibit it in petty ways.

Notwithstanding the free and easy form of management referred to, and the general latitude with respect to non-essentials that went with it, an onlooker would scarcely have been conscious of any lack of discipline or orderliness in the running of the organization. Unique in the large measure of autonomy allowed under it, the factory system developed largely by Rice was highly effective. In comparison with present day forms of management, with their elaborateness of detail, maybe it was faulty. If it was so, I can only say that it worked well in spite of its faults, or, without aiming to introduce a paradox, because of them. Its framework was altered from time to time to suit changing conditions, but many of its underlying principles have survived.

To describe the details of the Rice system would be to risk being tedious, yet a brief outline of its main features should assist the reader to understand the spirit of the General Electric Company. As I have elsewhere pointed out that spirit is my theme. The corporation that I have served for a lifetime has interest enough as a structure, but for me the soul that I could not fail to see in it, as I saw its structure rise, has a far richer interest.

For operating purposes the factories in the system had virtually the status of independent units. They

controlled inventories, regulated wages, compiled their own budgets, and kept their own accounts. Their products, shipped direct to customers under a simple internal order routine, were billed, at cost, to the central office of the company. With the aid of suitable records, operating conditions were watched and systematically analyzed from week to week, or from month to month, and by means of a physical inventory results were checked comprehensively once a year, any differences between input and output, at cost, as disclosed by the inventory, serving as a measure of efficiency. When a deficit was disclosed, its causes were ascertained and remedies were applied.

So highly autonomous a form of operation inevitably led to some lost motion. On the other hand, it gave boundless scope for the exercise of initiative. Whatever lost motion there was did not pass unnoticed, and in itself was deplored; but the value of the things that were incident to it was vastly greater than any saving which could have been effected by its elimination.

There was love of work among the engineers, mechanics, and executives that Rice drew about him. There was pride of achievement. There was mutual trust, with teamwork of a spontaneous and joyous nature. There was loyalty of the kind that men have for a cause.

Such a condition could not have existed without reasonable elbow-room. And perhaps the lost motion of which I have spoken was nothing more than reasonable elbow-room.

Most of the workers in the Rice group were quite young, but many were married. They were all ambitious enough in a practical sense, eager enough for pecuniary reward. And yet it seemed to be the atmosphere in which they thought and toiled, and, in friendly ways and under fair conditions, sometimes fought, that made them efficient. Pecuniary reward was not their sole incentive. It was acceptable, and was prized, but largely as a by-product of the game.

The factory managers were all members of a conference body known as a manufacturing committee. At the meetings of that body, which were held at first weekly, then bi-weekly, and later monthly, policies and procedures were discussed and agreements concerning them reached. Rice was its chairman, its outstanding figure, and its inspiration for two decades. It was a conviction of his, which came less from any detached study of management theories than from his intuitive knowledge of human interactions, that policies and procedures were more likely to be workable if introduced as a result of agreement than if given effect through orders. Because of that conviction the idea of industrial democracy was advantageously applied in the work of

the manufacturing committee of the General Electric Company long before it became familiar to the public.

An incident that took place at a meeting of the manufacturing committee, as far back as thirty years ago, should be of interest here. A plan for the relocation of manufacture affecting several communities, and a large number of employees, had been discussed for four hours. The members were weary and their views far apart. "Well, Mr. Rice," said one whose combativeness, and logic, too, had prolonged the debate, "what's the decision?" Rice could easily have expressed an individual judgment, and it would have been accepted as a decision; also, he was not at any time unmindful of his prerogatives; but, on the occasion of which I speak, seeing that there was more lasting good in a meeting of minds than in domination, this is what he said "The responsibility of determining what is good for the General Electric Company in this case rests with the men here assembled—all of them. What they agree is good for the Company will be the decision." He spoke dispassionately, in the tone of one making a remark about the weather But the effect of his words was dramatic They made the problem, which had been perplexing, and the cause of some irritation, seem easy of solution All that was necessary was the will to agree, and the will to agree, it was evident, could not fail to come with a sense of common responsibility.

The proposed plan was neither adopted nor rejected at that meeting, but the meeting was fruitful. The principle of group action, always a cardinal feature of General Electric administrative policy, was so simply, clearly, and persuasively enunciated that thenceforward no one could well lose sight of it. An agreement upon the plan, amended to some extent. was reached later; and the agreement was the decision. Its terms were recorded and complied with. No orders were given; none was needed.

Thus far I have been visualizing the factory system of the General Electric Company as it was familiar from 1892, when it comprised units at Schenectady, N. Y., Lynn, Mass., and Harrison, N. J., to about 1912, by which time units at Pittsfield, Mass., Bloomfield, N. J., Erie, Pa., and Fort Wayne, Indiana, had come into the picture. Units at Bridgeport, Conn , at Oakland, Calif., at Philadelphia, Baltimore, and Cleveland, and a second unit at Lynn have since been added; and small auxiliary units are operated at various other points.

The temptation to resort to the use of statistics in the telling of my story comes to me at this point, but for the most part must be resisted. Figures seem obtrusive, or at least irrelevant, when one is trying to reveal the spirit of an institution. For the enlightenment of those whose impression of the magnitude of the General Electric Company is vague, it may be said that the factories referred to employ between

60,000 and 80,000 men and women, the number varying with the volume of orders. They produce electric equipment of every description, ranging in size from the "grain of wheat" incandescent lamp used in surgical work, to a triple-cross-compound steam turbine with a capacity of more than 275,000 horsepower. The value of the products sold amounted to $12,000,000 in the year 1892, it reached $337,000,000 in the year 1928 and its annual rate is now greater than that.

The allusions made to an internal order system, and to a plan for the relocation of work may have caused the reader to wonder just how production was assigned to the different factories. Agreements were reached from time to time at the meetings of the manufacturing committee as to the logical points of manufacture for different classes of equipment, and orders, as they came from customers, were relayed to the factories in accordance with such agreements.

Opportunity to promote growth through local initiative was, however, always virtually unlimited. Each factory had a staff of capable research and designing engineers, and under the autonomous form of operation which has been outlined, these engineers constantly extended established lines of equipment and developed new ones. To some extent rivalry between the factories, of a friendly character, and for constructive ends, was fostered, but wasteful duplication was prevented by the manufacturing com-

mittee, which, on account of its representative character, was always an effective coördinating agency.

I repeat that the Rice system of management, as roughly outlined, was not free from defects, or from what efficiency engineers would nowadays class as defects. It will be recognized as the antithesis of the system under which some other well-known corporations have achieved notable success. But it was suited to the General Electric Company, with its diversified products, its need of many kinds of high-class minds, and its dependence upon group effort. Above all, it produced an organization whose members could be both human and efficient.

If this work were a conventional history instead of a more or less sketchy description of the spirit of an institution, and of some of its major achievements, it would be fitting to refer here to many interesting personalities. More than a score of exceptionally able men helped Rice, at different times, to develop the system of management to which his name has been applied. The most widely known of them were George E. Emmons, Francis C. Pratt, Cummings C. Chesney, Walter C. Fish, and George F. Morrison. Emmons, originally an accountant and later an influential executive; Pratt, long effective as an organizer; and Chesney, pioneer with Stanley in the design and construction of alternating current apparatus and a man of varied attainments, served successively as chairman of the manufacturing com-

mittee. Fish was an energetic, resourceful manager with engineering skill of a high order. Morrison, unpretentious, but thoroughgoing and stanch, built up the Edison incandescent lamp division.

The National Electric Lamp Company came into the General Electric group of selling and manufacturing units in 1912, bringing with it a system of management developed by Franklin S. Terry and Burton G. Tremaine. This system was unique, but its main features harmonized fully with General Electric procedure and General Electric spirit. In fact the National Lamp Company owed its success, as an independent enterprise, to a dovetailing of individual initiative and teamwork of which Terry and Tremaine, both of them men of broad vision, had made a science.

XIII

THE MAJOR MECHANISM

THE amount of publicity received by Rice was always meager in proportion to his influence. The advantage of a press agent may have been as clear to him as it is nowadays to many industrial leaders, but, from all appearances, he found posing a strain, and avoided it as one avoids any unnecessary strain. His standing with both official superiors and the men who worked under his direction was, however, always good. Lack of respect or trust never nullified his efforts. I recall but one criticism of him as an administrator, it was made in a variety of forms, its substance being that he was slow to render decisions.

An incident already related bears inferentially upon that criticism. It is quite true that decisions did not pour from Rice as they seemed to do from Theodore Roosevelt, for example, when that snappy statesman was the nation's chief executive. Rice knew the danger of premature decisions. Seemly reservation of judgment was habitual with him, and it was one of the secrets of his effectiveness.

Quickness of decision is often stressed without due regard to the different angles from which it may be viewed. There is, of course, no virtue in quick de-

cisions unless they are also wise ones. Second-rate executives, in their eagerness to be ranked as topnotchers, are, as a rule, ready, fruitful deciders. First-rate ones, the authentic topnotchers, rarely are. The statesman just alluded to may have been a topnotcher in many respects, but his impetuosity did not make him one.

In any event, the idea that I wish to convey is that the subject of these paragraphs, as head of the manufacturing and engineering department of the General Electric Company from 1892 to 1912, was a business executive of the highest type, irrespective of the speed at which it seemed to him feasible to make decisions. An engineer who was close to him throughout the period mentioned, on one occasion stated the case in this way: "The problems that Rice has to deal with are many-sided ones, and he is discerning enough to see that time, reflection, painstaking analysis, and above all, skill as a listener, are needed for their solution. It would be easy for him to make a larger number of decisions than can be placed to his account, but with a more imposing record of decisions, his record of accomplishment would be less noteworthy than it is."

The same individual at another time said, "Such men as make up the technical and supervisory forces of an enterprise like the General Electric Company need inspiration more than they need decisions.

Inspiration strengthens them; they are often weakened by decisions."

A coworker of mine once said to me, "When I lay a matter before Rice he does not tell me what to do about it, but after I have talked with him, I invariably find myself upon a trail that leads to a point where I am able clearly to see what I ought to do, and then I do it of my own accord, and with a feeling that I am of some consequence—a feeling possibly not unlike that which the youthful Alexander had when assured that some worlds were to be left to him to conquer!"

Well-known workers, such as the incomparable Steinmetz, Whitney, king-pin of research, and Emmet, brilliant turbine engineer and virile thinker, were, to be sure, richly endowed at birth. Yet how fortunate they were to have had, at the beginning of their careers, a chief who understood them, who knew how their minds could best function! Genuis had come to them from nature, and it was bound to flower at some time, and in some form. Rice created an environment in which it flowered quickly, and with an effulgence which it might not have had in many another environment.

Despite the admission that trigger pulling was not Rice's strong point, the fact is that he had a sharpshooter's aim, and enough quickness of decision when the circumstances made it fitting and necessary. He was forever on the lookout for improved forms or

mechanisms of management, and when he saw one, was prompt to recognize its merit and introduce it. The power, prestige, and value of the man were merely not due, in the main, to virtues inherent in mechanisms of any sort. They were rather a consequence of his peculiar philosophy of management, in which a human being was at all times accounted the major mechanism—the master key to efficiency—and was treated as such, with gain for him and for the cause he served.

XIV

INTEGRITY OF COSTS

A CASUAL use of the phrase "integrity of costs," by Rice, once drove me to the dictionary. I had previously thought of the word "integrity" as denoting exclusively a form of human conduct, or a type of human character, and hearing it linked to the word "costs" by a man to whom verbal distinctions were clear, wondered just what relation it bore to arithmetic. With the help of Noah Webster, I found that "integrity" not only signified purity of purpose and uprightness of conduct in an individual, but that it also signified completeness or wholeness of anything—of a nation, a suspension bridge, a building, or a column of figures. Then I perceived that "integrity of costs," instead of being in any sense a loose expression, was a singularly meaningful and happy one.

Forty or fifty years ago costs, as a rule, lacked "integrity," that is to say, they were not complete or whole. For the most part they were little more than rule of thumb compilations, which dealt with major outlays only, and not in any thorough fashion even with them It was rarely that they included allowances for such items as lost time and spoilage of materials. Sometimes an allowance for "incidentals"

was included in a compilation, but it was usually inadequate. There was no setting down and footing up of the "incidentals."

The average manufacturer who failed in those days failed because of the condition described. The costs by which he was governed lacked integrity. In the main his business may have been ably managed, but the attention given by him to the arithmetical branch of it was superficial or meager. He knew the rates of wages which he paid for labor, and, in fact, was more concerned about them than he had occasion to be. He was concerned, in shortsighted ways, about so-called high rates of wages; they made him shudder because he was unable to see that they were not necessarily inconsistent with productive efficiency. Also he knew the prices of the raw materials that he bought. And he was cognizant of certain expenses for supervision, for clerical services, for power, heat and light, for upkeep, and so on.

But his disbursements were to him as were primroses by a river's brim to the prosaic character in a famous poem. They were merely disbursements, nothing more. He gave little thought to their points of difference and, therefore, to their allocation. Such allocation as he attempted was in a large measure haphazard.

The leaders of the General Electric Company, during its formative period, were alive to the danger of haphazard procedure of every sort. "We ought

to know at all times what our products cost," said Rice a year or two after he had helped me, by the use of a striking phrase, to see integrity in things as well as in human beings. "To sell at little or no profit, or even at a loss, may be temporarily expedient, provided we are conscious of what we do," he added. "But to sell at a loss in the belief that we are making a profit is self-deception. To lower costs through increased efficiency of manufacture is, of course, essential, and it is what we are striving to do, but to lower them through the omission of some of their elements, cannot be otherwise than ruinous. We should know the full cost of each and every one of our products, which is but equivalent to saying that we should have knowledge of facts."

The General Electric Company, guided by the very simple principle thus enunciated, overcame many difficulties of an economic character which would otherwise have been insuperable. It was bold at times in entering new fields; it took chances and made mistakes; it sustained losses. Millions were expended by it for the development and manufacture of steam turbines, for example, before any profit was derived from their sale. And there were many other cases in which it made large outlays without any gain whatever except that represented by experience.

But the exact knowledge of the cost of each of its products, which it had from month to month, and from day to day, prevented drifting, with the in-

sidious waste that is inseparable therefrom. Its situation was never that of a mariner lost in an uncharted sea. Such deficits as were disclosed by its operating reports often assumed the aspect of investments, since, as a consequence of the deficits, its efforts to promote efficiency were intelligently directed. Articles which it saw were inherently expensive to make, and for which the demand was, therefore, slight, were automatically superseded by those of more economical design. It applied Darwin's theory to electrical devices. Production for profit was its avowed purpose, but hand in hand with the pursuit of the purpose went selection through trial, with standardization of the best.

Cost-keeping systems that insure integrity, completeness, or wholeness of costs are not uncommon nowadays, for cost accounting has ceased to be a fad or a fancy, and has become a science, as indispensable in any well-regulated business as skilled salesmanship. A comprehensive review of the cost system evolved by the General Electric Company, if made, would therefore contain nothing that would seem novel. One feature of that system, however—the mechanism through which cost of development is ascertained and distributed in prices—remains unique, and on that account will be briefly described.

XV

Development

THE GENERAL ELECTRIC COMPANY is not a manufacturer in the sense in which manufacturing is commonly understood, but is that and something more. It originates the products which it supplies to the public. In addition to executives, salesmen, and manual workers, its organization is made up of scientists, research and designing engineers, and inventors—men who contribute in one way or another to the development of apparatus and devices for the generation, distribution, control, and use of electric energy. Its expenditures for development during the whole period of its existence have exceeded $200,000,000.

Rice was thinking particularly of such expenditures when the phrase "integrity of costs" was used by him. He saw the importance of their intelligent control, and presently conceived the idea of segregating them so that they could readily be included in individual prices and equitably liquidated.

To give effect to that idea, so-called development jobs were instituted. Each of these jobs was supported by an appropriation granted after the purpose of the job, and the results expected from its prosecution, were carefully considered. The procedure was

analogous to that followed in the compilation of a budget. Appropriations for development jobs in reality constituted a series of budgets.

Each of the jobs was provided with an account to which expenditures were charged, and the expenditures were allowed to accumulate until such time as the article covered by the job—a motor, a generator, or a turbine, a transformer or a lamp, a switch or a key socket, or whatever form or type of electrical equipment it chanced to be—was ready for sale. When the appropriation was exhausted before that time, an additional appropriation was granted if a review indicated that continuance of the work was warranted.

With the article in question marketable, an estimate of its sales for a period of a year or more was made, and an allowance for development sufficient to insure liquidation within the period was included in the cost of the article, and, in turn, in its selling price.

In some cases the amount of actual sales was more than the amount estimated, and in other cases it was less, so that the rate of liquidation of development varied with different articles. The total unliquidated development, always a large sum, was classed as a contingent asset, but when, through lack of sales of the article to which it applied, any portion of it could not be liquidated, such portion was written off.

The aim was threefold, first to make each article, as it became salable, carry the cost of its develop-

ment; secondly, to spread such cost over a relatively large volume of sales in order to keep the price of the article moderate; and lastly to exclude from any part of operating cost, by writing them off, outlays for development which were unfruitful.

The treatment of development cost, which I have tried to describe in concise terms, was sometimes thought to be an over-refinement of segregation and distribution. There is no doubt, however, that it helped the General Electric Company to carry on its pioneering work with a large measure of safety, and, therefore, with effectiveness. Moreover, it was good for the electrical industry, inasmuch as it tended to keep prices consistent, stable, and equitable. The user of an incandescent lamp never had to pay any part of the cost of developing a generator or a transformer.

My thoughts revert to the expression "integrity of costs." As the reader has perceived, and as the dictionary long ago made clear to me, Rice was not confusing human conduct or character with arithmetic when he joined the words "integrity" and "costs." But quite apart from any question of etymology, the union of two such words had special significance. One can now see in it the peculiar spirit of the institution of which I am writing. For all practical purposes, "accuracy of costs" would have been no less expressive than "integrity of costs," and it would have been more conventional, but "in-

tegrity of costs" implied accuracy with a moral concept in the background. The founders of the General Electric Company were wide-awake business men, but they never lost sight of moral concepts. While Coffin and Rice knew the tricks of most trades, they employed their knowledge to circumvent tricksters rather than to play with them. No one, whether a customer or an employee, was able to gain their confidence through trickery of any sort.

RESEARCH TRIO

WILLIS R WHITNEY

WILLIAM D COOLIDGE IRVING LANGMUIR

XVI

WHITNEY: MAN AND SCIENTIST

THE GENERAL ELECTRIC COMPANY has been rich in scientific geniuses. References have already been made to Thomson, world-famous physicist and inventor, and to Steinmetz, equally famous mathematician. Ranking with those two in the class of geniuses is Willis R. Whitney, chemist and research engineer.

In spite of his brilliant achievements, and the recognition they have commanded, it is a chore for Whitney to visualize himself as anything more than a healthy boy, with a zest for work because of the downright fun to be found in it; or at most, an equally healthy man, with a curious and inquiring mind, but little else worth mentioning. While talking with him some years ago, I chanced to speak of his activities as having something in common with those of Steinmetz. "There's one fundamental difference," he said. "Steinmetz is a superman, whereas I'm a plodder of the garden variety—reasonably happy, to be sure, in my humdrum way, yet nothing more than a plodder."

Experienced writers, assigned to interview Whitney and tell the story of physical research, find him much more than a plodder, and say so in vivid phraseology.

The fact is that no more captivating personality is to be found in the big world of industry. One other thing must, however, be noted. In some of the published accounts of the man and of his work, there is a tendency, a little more than thinly veiled, yet obvious, to portray him as a freak—not, of course, a freak of plebian lineage, but one, rather, of blue blood or Brahman caste. Many of the popular sketches of Steinmetz were unfortunately marred by the same tendency. Perhaps there was some justification for it in the case of Steinmetz, whose peccadillos were at times pronounced, but there is none at all in Whitney's case.

Whitney, to be sure, is exceptional, so exceptional that the association of his name with a major corporation title—he was made a vice president of the General Electric Company in 1928—instead of increasing his prestige added prestige to the title. But there is nothing freakish about this "modern Aristotle," as he was once called by a disciple. In his work, in his personal habits, in his intercourse with those about him, he is quite as close to normalcy as a banker, a bookkeeper, or a baseball fan. To meet him in a trolley car, on the street, or at luncheon, is to encounter a cheerful, vivacious individual of midde age, who, in a modest way, is ready to contribute his share of tentative comment about the weather, the crops, or the stock market; about heredity, marriage, the rearing of children, or the cost of living, about

politics, books, inventions, or explorations; about prize fighting, bootlegging, or Indian lore; about art, biology, the nature of a vacuum, soil fertilization, the instincts of a turtle, red tape in business, the solar system, or the universe.

And whatever he says upon any theme, if it may be classed as peculiar, is peculiar mainly by reason of its rare quality. Whitney is original and versatile, not in any sense crotchety. His accent and gestures are indigenous but engaging. He employs homespun language, variegated and colorful, when either speaking or writing, and when speaking, crowds an unusually large volume of it into a given unit of time. Ideas form in such profusion in his fecund brain that they seem to press simultaneously for birth, giving to his words the auricular effect of machine gun fire. But in the apparent verbal jam, the ideas stand out as clear as crystal, and often, too, they are as gripping as anything in fiction.

Newspaper men, when writing of their visits to the research laboratory at Schenectady, feature Whitney's generosity toward his associates. Generosity is, of course, a fine thing, and Whitney is instinctively generous. But his attitude toward the men who work with him is rather that of a sportsman who loves fair play, and thinks it effective as a working principle, than of one who aims to practice generosity because it is classed as a cardinal virtue, or as chivalry

was practiced by the knights of the Middle Ages before Cervantes made it absurd.

The names of a number of workers in the laboratory are linked to achievements of far-reaching value, less because of the generosity of their leader, as generosity, than because of his sportsmanship, a quality in which eagerness to recognize and to develop merit, as well as judgment to appraise it and make it effective, are combined with generosity.

Yes, Whitney is instinctively generous. Of that there is no doubt. Yet with flimflammers and drones he can be a martinet. What is admirable in him, what endears him to his pack, and makes a stranger his partisan, is the Whitney sportsmanship.

I hereby advise anyone interested in psychology, as applied to industrial research, or to any branch of industry, to study this Whitney trait. Nothing is worthier of careful study. Whitney himself has never defined it, and quite likely is unconscious of its existence. If one were to mention the matter to him, his comment would probably be something like this:

"I a sportsman! Well, that's an interesting enough hypothesis and one which has heretofore escaped my notice; I'm glad you brought it to the laboratory; maybe it ought to be analyzed by Langmuir. I've been called many things in my time, and some things more than once, but to be christened a sportsman is at least novel. A man, you know, whether his name is Whitney or Smith, is an aggregation of molecules;

molecules are made up of atoms, and atoms contain electrons, a form of energy of which very little is known. It may be that the sportsmanship that you ascribe to me, assuming that it really is a part of my make-up, is this obscure form of energy—the electrons functioning in their mysterious way in the Whitney cosmos. If it is, what can I say or do about the case when we know so little of the nature of the energy. Some day, when we have much more information about matter of all kinds than we now possess, we may understand a lot of things about a Whitney or a Smith of which the most erudite physiologist has no conception."

But even if such a view were expressed by Whitney, the chemist, or by Whitney the man with a sense of humor, the Whitney sportsmanship would still seem as tangible as legal tender to those who know the man and have watched him in action as chief of the laboratory in which many of the weirdest dreams of science have come true. Language is flexible, and alternative phrases may be used to express an idea, a dominant human characteristic, or the sum total of an individual's influence. The Whitney sportsmanship may be said to be similar, in substance, to the Rice sense of justice, described elsewhere as the main factor in the upbuilding of the General Electric Company's manufacturing and engineering structure.

Whitney is primarily a scientist, searching diligently, and rather shyly, to find as many of nature's

secrets as he can, and get them utilized in the world's work, but any hard-boiled industrialist, anxious only to know how to make human beings efficient, that is to say, how to establish working conditions under which they feel that it is worth while to do their best, could learn more about the subject by spending a month in the research laboratory at Schenectady than by reading a stack of textbooks, or listening to a series of exhaustive lectures, on management.

A worker in the laboratory with whom I was recently talking, stressed one side of the Whitney sportsmanship. "I was at the hospital on the point of passing out," he said. "Whitney heard of my plight, left an important experiment upon which he was engaged, beat it to my bedside, and, through timely and intelligent suggestion, based upon such knowledge of medical science as he possesses, actually saved my life. In one sense that was probably not a matter of great moment, since my life may not be worth very much, but it illustrates the lively constructive interest that the man has in everything. He would have been as eager, of course with a different emotional impulse, to save a turtle's life if the turtle seemed to him to have potential usefulness."

Let us dwell for a moment more on the question of Whitney's generosity. That he habitually urges his men to advance toward the footlights, when important discoveries are announced and curtain calls come, cannot be gainsaid. On the other hand, these

men themselves, scientists of the highest type, and fully conscious of what they owe to their chief, often contrive, in ways of their own, to "return the compliment." One of them, L. A. Hawkins, on the occasion of the presentation of a medal to Whitney, gave the following description of him and of his laboratory:

"His most notable achievement has been the creation and development of the research laboratory of the General Electric Company at Schenectady. This laboratory, one of the earliest of its kind in this country, the embodiment of the application of science to industry, has gained a world-wide reputation by the quality of its work and the importance of its results. The results speak for themselves, but only those associated in the laboratory with Doctor Whitney can realize to what extent they are due to him personally, or how truly the story of the laboratory, from its inception with a small staff, to its present development with over three hundred workers, has been the story of his personal achievement. Its growth has followed naturally from the value of its accomplishment, but its accomplishment has been due primarily to him. His broad scientific knowledge, his ability as a chemist, his resourcefulness in experiment, his energy, enthusiasm, and optimism, combined with a clear sense of proportionate values, laid the foundation for and guided and inspired all the work of the laboratory, while his democratic

and magnetic personality created an *esprit de corps* in his staff which has been a powerful factor for success."

Whitney is the possessor of many titles other than those of vice president and director of research of the General Electric Company. For example, sometime ago he was made Chairman of the Submarine Board of the United States Navy. A number of colleges, too, have given him degrees. A list of these titles and degrees can doubtless be found, by anyone for whom they have special interest, in "Who's Who in America," or in any encyclopedia containing the biographies of distinguished scientists. In themselves they have for me relatively little significance. My aim has been to sketch Whitney as a great research engineer, and as the great man, in a simple way, that many believe him to be; and even if such accessories of his greatness as those mentioned gave me a thrill, space would not be taken here to catalogue them. Moreover, so far as thrills go, it is safe to say that Whitney himself has never received a thrill from the contemplation of any title, degree, or medal, as keen as that which comes to him when he notes the effect of the sun's rays on a morning-glory, of a changed environment on a butterfly, or of heat, under novel conditions, on a speck of tungsten.

XVII

Research Laboratory Founded

WHAT has been said of Whitney and of his work may have excited some curiosity as to the institution which is the man's monument, the famous research laboratory, situated near the Mohawk river not far from the spot where a band of Indians once staged a frightful massacre.

Interpolation is usually distracting, but it seems in order here to remark that archaeology is one of Whitney's hobbies, and that he is keenly interested in the crude implements of the American aborigines that lie buried in the soil of the Mohawk valley. Visitors to his country home on the Troy Road are always given an opportunity to inspect his fine collection of arrow heads.

But let us dwell for a moment upon the research laboratory and its origin. Whence and how came it? Whose conception was it? When did it start as a working unit? Whitney, to be sure, has made of it a workshop in which many of the familiar materials in our familiar world of matter take on relationships little less astonishing than those imagined by Lewis Carroll in "Alice's Adventures in Wonderland"—a workshop to which scientists from all parts of the globe are drawn as religious pilgrims are drawn to a

Mecca. And, what will seem vital to many who are not concerned with the adventures of an Alice, or with Meccas of any kind, and are not even scientists, but just dwellers on Main street, he has kept the activities of his fairy temple so closely akin to the time-honored operation of getting down to brass tacks, that it is a fruitful source of revenue to a great corporation, helping materially to earn the dividends that go to stockholders.

From the activities referred to came, for example, ductile tungsten, the economic benefit of which is enjoyed by everyone who uses an incandescent lamp, and by multitudes who run automobiles; the x-ray tube, now an indispensable tool of surgery; the vacuum power tubes which made long-distance radio broadcasting possible; and the gas-filled lamp, one of the two or three most important contributions to the art of electric lighting since Edison gave to the world its carbon-filament prototype.

To say those things is to give to Whitney the credit to which he is entitled; and it would be quite unlike him to expect more. The credit for founding the laboratory must be assigned to another. Rice founded it, or rather initiated the action that led to its founding.

The resumption of business activity, after the prolonged period of partial stagnation that followed the panic of 1893, was quite marked by the year 1899. Industrial leaders then dared to hope; some

were even courageous enough to lay out long-range plans for the future. Rice, still the far-sighted executive that he had been earlier when making the remarkable appraisal of Steinmetz, mentioned in another sketch, persuaded the directors of the General Electric Company to grant him a liberal appropriation to provide facilities for systematic research; and the first step that he took, after obtaining the requisite appropriation, was to hire Whitney, at a salary of $2400 a year, to organize and operate a department of research.

That hiring of Whitney was in effect the founding of the laboratory. I recall the incident as clearly as if it had taken place yesterday. Like many an incident to which things of great moment may be traced, it was not at all spectacular. Dewey is said to have opened the battle of Manila Bay with the remark, "When you are ready, Gridley, you may fire." About as simple and matter-of-fact is this closing sentence of a letter written thirty years ago by Rice to Whitney concerning the latter's employment. "Please let me know if the above agrees with your understanding; if it does, the correspondence between yourself and Mr. Steinmetz, this letter and your reply, will be a sufficient record of our arrangement."

As the quotation indicates, Steinmetz had a hand in the matter. Rice had consulted with him, as well as with Thomson, concerning facilities for

research supplementary to those which then existed and have since been retained at Lynn, and had had the benefit of their counsel. Also he had been aided by the suggestions of Albert G. Davis, patent expert, and a man of broad vision.

At the time of the momentous "arrangement" referred to, Whitney was teaching chemistry at the Massachusetts Institute of Technology. He had graduated from the Institute in 1890 and subsequently had spent two years studying at Leipzig and at Paris.

When the professor of chemistry exchanged his classroom for an obscure corner of one of the older buildings at the Schenectady Works of the General Electric Company, industrial research, which it was his task to organize, was virtually unknown. Hence the task was not an easy one. The Schenectady technicians, most of them electrical and mechanical engineers, were engrossed in problems of design and production, and on that account, and not because their minds were at all parochial, had no more than a distant or casual interest in research, as such.

So Whitney was obliged to be a crusader as well as an investigator and experimentalist. Three things, however, were in his favor First, he had more than a little of the honest enthusiasm and persistency of a born crusader, secondly, he had from the outset Rice's sympathy and backing, and lastly,

his work was quickly seen to be meritorious and useful. As a consequence, industrial research was applied cumulatively, and received steady recognition, from 1900 till 1912, by which time its status had become quite definite and secure.

It was in 1912 that a seven-story structure was erected to serve primarily as a home for the research laboratory. A six-story building was added in 1924.

Representatives of the press are stationed at Washington and other recognized news centers to tell the world what is going on, and, of course, much that they tell has interest, but if a competent reporter, with, say, a working knowledge of physics and chemistry, were to tell what is going on daily within the walls of those two buildings, how fascinating and revealing would be his stories! Readable comment continues to come from the recognized news centers, for there is no dearth of talented writers to make the familiar seem novel. Nowadays, however, it is in the research laboratories, like that of the General Electric Company, that vital news is made. It is there that Nature, patiently and reverently wooed, is disclosing her secrets.

Perhaps I should point out in passing that this sketch is confined to the laboratory with which Whitney has been peculiarly identified, the laboratory whose achievements in research, while ranking high with scientists, have also stirred the popular imagination. A multiplicity of sketches would be

necessary fully to describe the pioneer engineering activities of the General Electric Company. A long-established unit now known as the general engineering laboratory, for example, does work more or less analogous to that of the research laboratory, but closer to the stage of commercial development. At its head is Louis T. Robinson, one of the technical geniuses of the General Electric Company, who has functioned largely as a collaborator and coördinator, and whose name on that account is relatively unfamiliar to the lay public. Many of the early experiments in connection with radio and photophone mechanisms were initiated and carried on in the general engineering laboratory.

XVIII

Bacon's New Atlantis

FRANCIS BACON, classed by scientists as the prophet of modern research, thought the Greek philosophers had spent too much time merely theorizing. Their major purpose seemed to him to have been to provide topics and stage-settings for interminable dispute, most of it of a repetitive nature, like the motion of a merry-go-round, and having results no more substantial than those which can be placed to the credit of that contrivance. He lived several centuries before the advent of railroads, the telegraph and telephone, wireless communication, radio, electric light, and the automobile, but it seems reasonable to assume that those imposing instrumentalities of convenience and well-being for man were dreamt of, in some form, in his philosophy. Frequent reference is made in his writings to "commodities" and "fruits," as distinct from the mere speculation which had occupied so much of the time of the thinkers who made ancient Athens an intellectual center.

In one of his books, New Atlantis, was described a fanciful kingdom, the basis of which was an order, or society, designated as Salamon's House. This institution had many of the earmarks of an up-to-

date research laboratory, operated by men skilled in the physical sciences, and equipped with every known tool and chemical for the carrying on of investigations and experiments. Its personnel was divided into working groups, each of them having a specific form of activity to pursue. There were nine in all. One group assembled and classified available data, another planned and conducted new experiments, a third traveled beyond the confines of the realm and brought back information for analysis and comparison, a fourth appraised the results of investigations and experiments and determined how they could best be applied, a fifth charted new paths of investigation, and so forth. The end sought was, in Bacon's language, "a knowledge of causes and the secret motions of things; and the enlargement of the bounds of human empire to the effecting of all things possible."

If the author of New Atlantis were to return to life, after his sleep of three hundred years, he would be much less bewildered than was Rip Van Winkle, back from the mountain after his nap of twenty. Visiting Schenectady, he would find the research laboratory there very much to his liking; he would see carried on diligently and systematically in its huge buildings the search, only imagined by him, for "a knowledge of causes and the secret motions of things"; he would have the pleasure of mingling with groups of trained men zealously doing sundry chores

like the ones which had been assigned to the "fellows" of Salamon's House; and presently he would be made agreeably muzzy by a veritable feast of the "fruits" of which he had written with a seer's enthusiasm.

And if someone with a literary bent were to draw the distinguished visitor's attention to a paper that now lies before me, I believe he would read it, not only with understanding, but with the fervent satisfaction with which one reads anything that throws light on one's hobbies I refer to a paper contributed by Whitney on the occasion of the presentation of the Perkin medal to Langmuir, inventor of the gas-filled lamp.

"When Langmuir first told me he thought he could make a better tungsten lamp by putting gases into it than by trying to further exhaust it, I thought he was dreaming," says Whitney in the paper mentioned. "And so he was. But it was the kind of dream he could make come true. Nothing had seemed more improbable a few months earlier. Through his study of conduction and convection of heat by gases, combined with the laws of radiation of energy from hot filaments, he decided that a filament could be made large as a light giver and relatively small as a heat loser. He had already determined the beneficial effects of gases in reducing the rate of evaporation of tungsten at high temperatures, and so, by coiling the fine tungsten wire into a helix, so that its entire surface gave light, while the heat losses were only

those of the short cylinder defined by the wire, he was enabled to make the reduction in the cost of light previously mentioned."

That testimony is likely to interest anyone, scientist or layman, because of its authoritative source and informative character. But here are the paragraphs in Whitney's paper which would give the reincarnated Bacon a thrill, and supply him with a pretext for asking that he be rated as a modern:

"There is something in Langmuir's work that suggests, by sharp contrast, an oriental crystal gazer seated idly before a transparent globe and trying to read the future without doing anything about it—a hopeless philosophy. In my picture an equally transparent and more vacuous globe takes the place of the conventional crystal sphere. It is a lamp bulb, a real light source. Langmuir boldly takes it in his hand not as some apathetic or ascetic Yogi, but more like a healthy boy analyzing a new toy even as Langmuir himself studied and fixed the complex watch of his boyhood days, but seeing visions, too, of many new things. There might have been nothing in that vacuum, but he was driven by insatiable curiosity to investigate and learn for himself.

"Thus he peopled that empty space with new and strange little beings or personalities which he had first dreamed of, then devised, and finally endowed with real character—and all this solely to make his various dreams come true. He first dreamed that

tungsten atoms were being carried by disreputable foreign atoms (oxygen) from the filament to the glass to obstruct the light. These were parts of disobedient water molecules which had not come out when commanded. They were divorced by the filament and were bootlegging tungsten in the one place in the world where a dry law was absolutely necessary. He dreamed of banishing or imprisoning these bootleggers. When Langmuir made this dream come true we got good, clear, long-lived tungsten lamps.

"Still he dreamed, with both eyes on the ball, of a greater light. Therefore he populated the lamp bulb with new beings, rare gases of dependable character, like nitrogen or argon. His divorced water molecules had taught the danger of affinities, so he chose for this new lamp investion a great horde of argon molecules. These had no affinities and are never divorced because they never marry. By this method the light he foresaw in the bulb became just twice as great as it was before, and all of us now easily see it, and the world is glad to pay for it.

"Gazing into the same sphere again, he dreamed about disembodied electricity, and soon the reliable little electrons were tamely obeying special laws—laws that had never been known before and that most men do not yet understand. He gazed again and saw outlaw atoms coöperating with his electrons, so that he was able to add to the thermionic servants of the radio sphere accurately controlled groups of electrical

helpers in the shape of gas ions, and thus he continually improved radio tubes.

"Here lies the difference between the ancient and the modern seers or prophets. The modern prophet is a doer. No one can fix the best ratio between thinking and doing. The pure thinker is apt to think too much and the active man to be too active. Evidently that Mendelian law which determines mutations and produces increased strength by cross-breeding explains why a certain mixture of thinking and acting yields greatest products."

Bacon in his lifetime seems to have been austere. From his picture one would guess that it was not easy for him to smile, although, scientist and thinker that he was, the childish notions and practices of the world of his day must have afforded him some amusement. And reborn, as we are now fancying him, he would probably react normally to the humor of our age. Maybe that whimsical account of an epochal invention just quoted, while reviving his interest in the "secret motions of things," would also cause his puritanical countenance to relax. Some of the expressions employed by Whitney might, to be sure, momentarily baffle him, for marked changes of terminology are brought about by the whirligig of time. For example, to understand precisely what happened to the tungsten, he might have to ask what was meant by "bootlegging" the metal. A brief explanation would, however, suffice to make that procedure

clear. While there was no ban on booze in the sixteenth century, operations corresponding to those carried on by a modern "bootlegger" were not unknown.

In any event, the general effect of Whitney's paper upon Bacon would be to whet his appetite for descriptions of other "commodities" and "fruits," and he would be supplied with a long list of them to obtain from the libraries and read at his leisure. Then he would be escorted from one end of the laboratory to the other to inspect its marvels, and, at the end, with the modesty of true greatness, he probably would say, "How vast, indeed, have been the strides made by physical research! And how far, too, have they surpassed the predictions made by me in my former embodiment. A prophet, forsooth, was I, but withal a feeble one. How inadequate, for example, was that New Atlantis of mine! When written, it was thought to be visionary, but evidently the wings of my fancy were as weak as those of a fledgling attempting its first flight. Had I portrayed for my skeptical contemporaries the things which I now behold, instead of becoming Chancellor, I would have been adjudged a lunatic. For my time I may have had what would be called in present-day vernacular a hefty hunch, but nothing more"

Of course, the research laboratory at Schenectady was founded to carry on industrial research, whereas all kinds of research were contemplated in Bacon's

scheme. It would, however, scarcely be pertinent to stress that point to the disparagement of industrial research. The fact is that industrial progress promotes and is often dovetailed with other forms of progress. The Coolidge x-ray tube, to give one illustration, is a commercial device in the sense in which a shoe lace or a golf ball is a commercial device, yet how vast is the debt that civilization owes to it!

XIX

CONTROL OF FEVER

SALAMON'S HOUSE, the research laboratory of Bacon's imagination, contained, among many other things, "chambers" in which different gases were experimented with and used for "the curing of divers diseases, and preservation of health." I recalled that detail when, in the course of a talk which I recently had with him, Whitney spoke of the possibility, suggested by the results of experiments on fruit flies, of safely producing a febrile condition in the human body by means of a short-wave high-frequency current of electricity.

"If," said he, "we could raise the temperature of the interior of the human body, as a fever does, and as a warm room or exposure to the sun, of course, does not, no one can tell how much it would help us to combat disease and lengthen life. What is known as fever is, so far as I can see, a symptom of conflict between deleterious organisms that have entered the system and beneficent ones maintained there by nature to repel invasion. As the conflict rages, there is high temperature, since motion in any given area generates heat there.

"Now, if we could learn how to generate, at will, and of course with entire safety, the particular form

of heat known as fever, we would naturally seek to become better acquainted than we now are with nature's defensive organisms, and probably obtain control of them. Control might, in turn, enable us to increase their effectiveness as fighters, and thus either prevent conflict, of which fever is a symptom, or shorten its duration. In other words, we might either forestall disease by setting up a powerful resistance to germs, should they enter the body, or conserve bodily vitality through a quick destruction of invading germs.

"With any conflict between invading germs, in their normal state, and the organisms of defense, mobilized and artificially strengthened for their work, there would of course, be fever, but it would be wholly corrective or curative. Since the fight would be one-sided, and, therefore, brief, the fever would instantaneously abate, or rather be abated, through the pressing of a button, leaving no damage, such as often follows in the wake of a fever which is normally protracted because of protracted conflict between two sets of organisms of equal or nearly equal virility.

"In one word, the aim would be to make electric energy an effective ally of the human body in its combats with its enemies."

I spoke, inquiringly, of such things as curing a cold in its incipient stage, bringing down blood pressure, arresting malignant growths, and retarding

disintegration of tissues and fatigue of glands. But Whitney evidently fearing that, like a typical get-rich-quick artist, I was taking leaps and bounds which were unwarranted, reminded me that he had but casually touched upon a possibility. "As yet we know very little about the fever phenomena," he added with the caution of a conscientious investigator, "so don't write feverishly of the subject, if at all. Our mission as researchers is to hunt for facts, not to raise hopes that may never be realized. The clue that has come to us in this case may be a false one. Occasionally we have been misled by false clues, and jumping at conclusions, save with a determination to weigh and check them, is a form of gymnastics that we must guard against.

"Some day we may be able to prevent or cure disease, and at least retard ageing, through the employment of electric energy to produce fever in the human body, but no device to do the trick is ready for the market. We are curious about the matter, we have expectations galore, and we have more or less data to be studied and used as the basis of tests, which require time and patience to make, and without which little can be known."

Such is physical research. Certainties are not its chief stock in trade. Dealing with certainties is relatively easy. The nicer and more arduous task of finding out what is certain is the one that physical research principally essays.

Danton raised the enthusiasm of France to the highest pitch it reached in the Revolution with the words, "To dare, and again to dare, and without end to dare." The spirit of those words is not precisely the spirit of a researcher, but they reflect his point of view. He would paraphrase them and adopt the less-belligerent slogan, "To try, and again to try, and without end to try."

XX

Let There Be Light: Langmuir

THE gas-filled lamp, playfully but lucidly described in the quotations from Whitney's paper, is in many respects one of the most important of the "fruits" of modern research. It came into general use, after its invention a dozen years ago, with relatively little ado. Few of the millions of people to whom it is a blessing recognize it in any distinctive way, a fact which may, in part, be accounted for by the present abundance of material blessings, but, looked at casually, the "gassed" lamp really does not seem radically different from Edison's incandescent lamp, throughout a generation as familiar as a household clock, for the very simple reason that the difference is not visible to the naked eye. We cannot see a vacuum. We cannot see nitrogen or argon. And since the difference between the old and the new lamp is the difference between a vacuum and inert gases such as those mentioned, it is not to be wondered at that the average mortal fails to apprehend it. Such a difference can be seen only through the mind's eye.

Creative workers, such as artists, poets, inventors, and researchers, habitually employ that sort of eye. Without it they would be as nearsighted as other

folks, with physical eyes that function normally but are of limited range and penetrating power. At times the use of the mind's eye lays the creative workers open to the suspicion of being nuts, but that point evidently seems to them irrelevant, or of but minor account. From all appearances they are content to be known as nuts so long as they enjoy the unrestricted use of the mind's eye, with its great range of vision—vastly greater than that of the most powerful telescope.

The lamp popularly known as Edison's lamp was a glass bulb with the air taken out of it, and with a filament of carbon, for the reception of electric energy in the airless space. Experts, I dare say, will not accept that description as literally correct. True, it is a rough and ready description, but it will do for all practical purposes. In reality all of the air was not taken out of the bulb, but only the greater part of it. An absolute vacuum, long the dream of incandescent lamp and other engineers, remains unattainable.

A filament of tungsten was also substituted for the carbon filament—for a time with only a slight measure of success, because of the inherent brittleness of tungsten, and later, after Coolidge had discovered how to make that refractory metal ductile, with complete success.

The gas-filled lamp, like Edison's original lamp, is a glass bulb; but it has the latest form of filament,

tungsten helically wound and heat regenerative, in place of a filament of carbon; and its enclosed space, instead of being a vacuum, or a partial vacuum, is, so to speak, charged with nitrogen and argon.

This lamp gives a whiter and more pleasing light than that which came from the vacuum lamp, with either the carbon or tungsten filament. Its economic advantage is, however, even more marked, that is to say, it yields a much greater quantity of light for a given amount of energy passing into the filament. A calculation made relating to this point indicates that the cost of light produced by the lamps sold by the General Electric Company in the United States in the year 1927 is $300,000,000 less than would have been the cost of a similar quantity of light produced before the introduction of the gas-filled lamp. In other words, with wealth visualized as effects produced, irrespective of the extent to which the effects are capitalized, or are immediately usable, the country's wealth was increased by the gas-filled lamp to the extent of $300,000,000 in one year.

Not much more than fifty per cent of the lamps referred to, it should be explained, were of the gas-filled type. Lamps of sizes less than 50 watts, which, of course, are manufactured and sold in large quantities, are still of the vacuum type, since the use of gas would lower rather than raise their efficiency.

"An atmosphere of nitrogen and argon is both a disadvantage and an advantage," said Langmuir,

when I asked him why the efficiency of the smaller sizes of lamps could not be increased, or why it would be actually reduced, through the "gassing" process. "When gas is introduced into a lamp taking energy of less than 50 watts, the disadvantage is greater than the advantage. When it is introduced into a lamp taking energy of 50 watts or more, the condition is reversed—the advantage is greater than the disadvantage."

Langmuir's categorical explanation of the fact thus stated was both fascinating and clear, but I shall not attempt to repeat it, either in the technical terms employed by him, or in lay terms. The fact itself appears to be quite well established, so that supporting data would be superfluous here. The explanation related to the varying influence of gases upon tungsten wire of different diameter, density, or form, with a given input of energy. And that point, moreover, is touched upon revealingly in the extracts given earlier from Whitney's paper.

Langmuir remarked that some day ways may be found in which to increase the efficiency of the smaller sizes of lamps through "gassing." And he could scarcely have said anything else and be true to form. A full-fledged researcher, as may be inferred from what has been said elsewhere, is not prone to concede that anything is impossible, so long as a single one of its factors has not been fully accounted for. His job is not so much to make a goal as to ex-

plore the infinite; his ambition, not so much to absorb recorded knowledge, though he absorbs a lot of it, as to ferret out the unknown, and swell the sum total of the world's knowledge.

One of the effects of the gas-filled lamp which may be expressed in social as well as economic terms, is an expansion of the field for artificial illumination. The floodlighting now common in myriads of forms, and the marked increase of visibility of stereopticon, motion-picture, and similar exhibitions, during the last decade, became possible because of the power and brilliance of this type of lamp.

I use the word "power" broadly to express the meaning carried by the old-fashioned term "candle power." Lamp engineers, when considering volume or quantity of light, or light efficiency, speak of "watts input," "lumens per watt," "visual efficiency," and so on, and they appear to understand one another. "Candle power" will, however, do here for a simple comparison.

A tungsten-filament gas-filled lamp, taking no more energy than was taken by a carbon-filament vacuum lamp, gives much greater candle power, but, apart from any difference of efficiency, a much larger lamp is commercially practicable with the modern type. A carbon-filament vacuum lamp of more than 32 candle power was not commercially practicable, whereas a tungsten-filament gas-filled lamp, having

candle power hundreds of times greater, is commercially practicable.

A lamp is now used for airport illumination which gives a volume of light equivalent to 30,000 candle power; one is used for motion-picture studio work which gives a volume of light equivalent to 100,000 candle power; and it is expected that a lamp giving a volume of light as great as 160,000 candle power will soon be commercially practicable.

In one sense, to be sure, such extended application of electric energy was a result of cōordinated effort, for industrial research is not carried on by Robinson Crusoes, but is rather an organized activity. In another sense, however, it is quite correct to say that the extended application came about because Langmuir boldly took that lamp bulb in his hand, "not as some apathetic or ascetic Yogi, but more like a healthy boy analyzing a new toy," focused his mind's eye upon its empty space, and, by deftly influencing the interactions of "the strange little beings and personalities" that he found in the space—with the aid of others that he introduced—made light cheaper and more abundant than it had ever been made before.

The author of Genesis reports that our first illumination came through a simple command, "Let there be light!"; but the report may be meager. It seems strange that an operation so momentous should have been performed in so offhand a fashion. It may

be that the command, whose authenticity I do not presume to question, was preceded by some sort of preparatory motions of which a record is lacking. Chemists and physicists appear to have cut no figure in the early doings of the race, and it is possible that at the time of the creation, as it is described in the only account of it that we have, none existed. Then again, some of them may have been about, searching for "the secret motions of things," but were too lowly for notice by the old-time historians. In any event, Langmuir is lucky that he came late enough to have his stupendous achievement chronicled in the ample phraseology of twentieth-century patent attorneys. There need never be any doubt of what he did.

XXI

Conquest of Tungsten

THE fact that tungsten is but incidentally mentioned in the description of the gas-filled lamp implies a certain lack of sequential treatment. Telling the story of the lamp without setting down the recent history of the metal, at least in a compendious way, is likely to strike those versed in the art of lamp making as a case of putting the cart before the horse; for the gas-filled lamp, with its filament of tungsten, helically wound and heat regenerative, could not have been developed by Langmuir if Coolidge had not previously discovered how to make tungsten ductile.

I can only assure the initiated that I have not meant to minimize the importance of Coolidge's work, but have just been tardy. I shall now touch upon the salient features of that work, and thus give to tungsten, reconstructed and made ductile by the Coolidge process, its rightful place as the forerunner of the gas-filled lamp.

The feats of research engineering are sometimes said to be romantic. They are, in truth, romantic; and none is more richly so than the conquest of tungsten—the conversion of one of the most refractory metallic substances known to chemistry,

into a fine wire or thread, as pliable as a willow twig and tougher than steel. It was in the wake of that conquest, made in the seclusion of the Schenectady laboratory, that the gas-filled lamp came—an agency more effective than tallow or wax, than oil, or gas, or carbon, to take on part of the sun's work when darkness is upon the face of the deep.

Nor is it telling a complete story to tell of that beneficent agency, the gas-filled lamp. While the conquest of tungsten gave to man the gas-filled lamp, it gave to him other things worth pondering over. It provided him with new means to facilitate the cure of disease and the treatment of bodily injuries—the x-ray pictures that enable physicians readily to locate malformation, fracture, and in some cases infection, and to determine their character. And it brought to him the radio in the form in which it now supplies him with useful information and ministers to his pleasure.

That such blessings, as they are now enjoyed, came from Coolidge's conquest of tungsten can scarcely be doubted, since the effectiveness of the x-ray tube, and the radio tubes, is due to the use of tungsten for targets and cathodes.

Furthermore, Coolidge's work gave to the automobile its present operating dependability. The tungsten contacts, now a part of virtually all ignition systems, insure greater certainty of action than do contacts of any other material.

What is tungsten? How long has it been employed in the mechanical arts? And what was the nature of its conquest?

Tungsten was discovered about 150 years ago, that is to say, its presence as a constituent of wolframite, cheelite, and other ores was first noted by chemists about that time. Its extraction as an oxide from the ores, and its reduction from an oxide to a metal, were followed by successive attempts to make it serve useful purposes. But for a century these attempts were largely futile because of the hardness of the metal, which equals that of the hardest steel, and its extreme brittleness and unmalleability.

It was a Swedish chemist who originally identified tungsten in an ore, which accounts for the fact that the term itself is Swedish. The English equivalent of "tungsten" is "heavy stone."

Near the middle of the last century the metal was demonstrated to be useful in alloy form, and it is used in one of the alloys now employed in the manufacture of steel for magnets and high-speed cutting tools. Raw tungsten, as an article of commerce is available in several forms, a description of which, however, would not be pertinent here.

What has been called the conquest of tungsten was the finding of a way, through a series of painstaking studies and experiments, in which to make the metal ductile. To describe the conquest I shall

use the words of the man to whom credit for it is due. They will be informative words, modest and matter-of-fact in tone—strikingly in contrast with the language in which early oriental rulers were wont to inscribe their exploits on parchment, obelisks, and tombs.

"Why pick on me alone?" said Coolidge quizzically, when I remarked that authoritative textbooks had long taught that tungsten was not pliable, and asked him to tell how he had contrived to turn the trick. "In the first place, whatever I may have done, I did with the assistance of a staff of able workers, and, secondly, we all had the advantage of facilities for exhaustive research provided by a financially powerful and forward-looking corporation."

"All of which may be taken for granted," I interposed, "and yet, back of any invention of supreme importance is a major intelligence, and, in the case in hand, it seems to be conceded that you are that major intelligence."

The genial scientist was plainly embarrassed but evinced a readiness to comply with my request, and there follows a digest of what he said:

"In view of the high melting point of tungsten, which is more than twice as high as that of iron, we saw that if it could be formed into fine wire, strong and pliable, it was bound to have immense value for use as a lamp filament. It scarcely need be said that at the outset we were not certain that it could

be so formed; we had faith that it could be; and with our faith went the effort through which the faith was shown to have been justified.

"Recognizing that knowledge of the characteristics of a metal, under all conditions, must precede knowledge of what may be done with it, we resolved to learn more about the characteristics of tungsten than anyone knew. Much information concerning this metal was available, but for our purpose more was essential.

"Our first step was to convert it, by sintering, from powder into a workable ingot—a form, you should bear in mind, in which it was still brittle, nothing having yet been done to obtain ductility. Then we applied to it successively various degrees of temperature above that of room temperature, and up to the melting point of iron, put it through a swaging, rolling, and drawing operation at each temperature and noted the chemical and structural effects indicated at the different heating stages as well as between these stages when the element was cool or at room temperature. Our work, in short, in its purely visual aspect, consisted of a series of mechanical operations, or steps, each step leading to another.

"Maybe I should here observe that a complete picture of research activity of any kind must of necessity have a crisscross appearance, for, in the nature of the case, such activity never follows straight

lines. For example, initial experiments made with tungsten combined with other materials led to the production of a filament, through an amalgam process, in which cadmium, mercury, and tungsten powder were employed. Large numbers of lamps containing this filament were made and sold. But the filament produced through the amalgam process, like a tungsten filament, which, unknown to us, had been developed abroad, and was also used in a lamp with measurable success, was brittle and fragile; and with us, the major problem was how to produce a wire that would not break from the shocks to which an incandescent lamp is often subjected.

"It was that major problem that I had in mind when speaking a moment ago of successive mechanical operations. The filament produced through the amalgam process has an important place in the history of electric illumination, but it was non-ductile and therefore unsuitable, under many conditions, for use in an incandescent lamp.

"The mechanical operations performed upon tungsten, in our quest to find how it could be made ductile, were continued for a long period, so that we accumulated large quantities of information upon which to base conclusions. For a time our conclusions were tentative. Many of them were seen, upon analysis, or with the aid of newly found data, to be erroneous, and, of course, had to be abandoned. Others, partially correct, were a stimulus

for added study and experiment, for every glimmer that we had of the secret or combination we were searching for made us increasingly eager for a full view. Our task was analogous to that of a biologist hunting for missing links with which to perfect an hypothesis; but, of course, our purpose differed fundamentally from that of the biologist, since we were not seeking to find anything that was missing, but rather, as it were, to disarrange the tungsten particles and rearrange them, with the object of creating a structural state in which the metal would be both ductile and tough.

"We at length created that structural state—and there is really little more to say. It is pleasant to know that our accomplishment has been of value, but don't risk spoiling us by praising it too much. We see in it rather the fruit of hard work than of genius—unless hard work and genius are one and the same thing."

The originality of Coolidge's work was revealed as he dwelt, at one point, upon the details of the process that bears his name.

"Unless the tungsten starting body, or ingot, is just right," he said, "it cannot be worked; even if it is just right it cannot be worked without tools that are just right; and even if the starting body and tools are just right the material cannot be worked without technique that is just right. In the beginning we did not know anything about starting

body, tools, or technique. Furthermore, we even did not know that the metal was capable of being worked at all.

"Reference was made a moment ago to the biologist and his search for missing links, but maybe a better analogy is to be found in the locksmith's art.

"Imagine, then, a man wishing to open a door locked with a combination lock and bolted on the inside. Assume that he does not know a single number of the combination and has not a chance to open the door until he finds the whole combination, and not a chance to do so even then unless the bolt on the inside is open. Also bear in mind that he cannot know anything about the position of that bolt until he finds the combination, and that he cannot tell whether a single number of the combination is right until he knows the combination complete.

"When we started to make tungsten ductile, our situation was like that with which such a man would be confronted."

I remarked that if the work described had been undertaken in the time of Job, he would not have been the only man to find a large measure of patience requisite.

"There is no doubt that our work called for a lot of patience," said Coolidge, "though perhaps not quite so much as Job was obliged to practice. Our initial experiments were followed by many disheartening failures, and, as I have already pointed out,

it was only after a long period that we discovered the combination that we sought."

"Your metamorphosis of tungsten," I said, "leads me to think of possibilities such as that of turning a squirrel into a kitten."

"That idea would probably make the opponents of vivisection shudder," replied the inventor, "and scientifically viewed I fear it is far-fetched. New types of animals have been produced by cross-breeding, but a scientist attempting, by mechanical means, to turn a squirrel into a kitten would not get very far because he could not, without destroying them, subject living organs and tissues to high temperatures, hammering, or very rough treatment of any kind. When changing tungsten, as it had long been known to chemists and metallurgists, into something else, that being what we really did, we were dealing with dead material, which we could heat, hammer, roll, or draw to any degree necessary for our purpose, namely, the creation of an entirely new combination or structure—one which had not previously existed either in nature or as a manufactured product."

Coolidge's account of an invention the effects of which have been far-reaching, illustrates again the spirit of research. It illustrates, too, the spirit of the General Electric Company, which, by recognizing the vast importance of research, has helped to give it a place in the sun.

XXII

Coolidge

THE man who discovered how to make tungsten ductile is himself an interesting character and calls for passing comment. Despite the feat that has given him distinction, he is so unpretentious that the sight of a bouquet meant for him would make him blush. His physique is small, and slightly frail, but wiry. In the pursuit of his investigations and experiments, he has the naïveté and zest of a boy searching in the woods for a bird's nest.

While talking with one of Coolidge's colleagues I asked him for his view of the human side of the inventor. "The man oozes optimism of an inspiring brand," he said; "you feel in his presence that if all things are not possible, many are. Yet he has plenty of circumspection, with a verifying, sagacious mind that readily isolates what is either impossible or extraneous."

I wish to heed Coolidge's plea to refrain from over-praising him for what he did to tungsten. Nevertheless a word as to the lasting value of his best-known achievement seems fitting. How will the historian of the twenty-first century, let us say, deal with it? No one can tell, but anyone may guess. My guess is that it will receive from that far-off chronicler more

copious treatment than he will give to many another achievement that looms large to living men. Looking back a hundred years upon the events of the last century, he may vouchsafe a few lines, or a paragraph, to this or that military triumph, for example, but it is a safe bet that he will devote pages to the conquest of tungsten.

I spoke of guessing, and a guess should have some basis. The guess just given is, in part, based upon the assumption that, with time, man's triumphs over man will be more and more eclipsed by his triumphs over nature. Even now warlike deeds stir men's emotions less than they once did, and it may be that ere long they will seem like child's play in comparison with the daring efforts of science to conquer the mighty forces yet hid from human eyes, but capable of being harnessed to serve human ends.

XXIII

A Conference Recalled

THIS history is not of such a character as to call for either the set textual arrangement or the textual balance of an encyclopedia. A considerable amount of space has thus far been given to typical achievements of research, but perhaps not inappropriately so. Research is inherently interesting and fundamentally important. However, I wish to accord adequate recognition to other subjects which are pertinent to the history, and shall here turn to one which has never lacked interest, but is invested with much greater importance now than it was forty or even twenty years ago. I refer to the subject of human relations.

Once upon a time—to use a hackneyed term that saves the labor of looking up dates—four General Electric supervisory workers, a sales manager, an engineer, a superintendent, and a foreman, conferred from ten o'clock in the morning until after the usual quitting time. Their purpose was to ascertain how to manufacture, at reduced cost, a line of motors which was relatively unprofitable because of severe competition.

Available manufacturing capacity was compared with current rate of orders, expected growth was

factored, and a painstaking study of space, equipment, and personnel made. Finally, a plan suited to the situation was formulated and agreed to. From all appearances a good piece of constructive work had been done.

A few days later the subject was reviewed with a fifth man, whose duties were related to the work under consideration, but who had not been able, because of a mission elsewhere, to participate in the initial conference. He was capable, but a stickler for routine.

"The plan outlined is a splendid one," said this fifth man, "and I heartily endorse it, but before any move is made, we of course must see what the boss, who will be away for a week, thinks of it."

One of the four who took part in the first conference yawned impressively, and, for a moment, seemed to be experiencing that poignant form of distress that comes to the captain of a juvenile baseball team, who, upon approaching the vacant lot designated as the scene of an important contest, finds the entrance thereto guarded by its owner.

The member of the group exhibiting these symptoms of anguish was the engineer. "We must see what the boss thinks of it, must we?" said he, and, after a brief, dramatic pause gave vent to his feelings with the remark, "Oh hell! that simply blocks our game! All that we can do, under the circumstances, is to sleep for a week awaiting orders. And the case

may be even worse than that; the boss may be detained beyond a week."

The exclamatory part of that comment startled no one, for engineers, while concerned ordinarily with things that are known or knowable, sometimes employ the terminology of a region concerning which our recorded data, while voluminous, are quite vague. However, there ensued a discussion of an hour or more, during which nothing whatever was said about the production of motors, and much was said about corporate management. The caption chosen for this chapter was suggested by that discussion.

The engineer, being the one to whom the prospect of delay was acutely irritating, naturally did the lion's share of the talking. "Four men of known experience, and presumably intelligent," he argued, "having spent an entire day deliberating on a problem, and their minds having met, what gain can come from deferring action until the boss, who, we are informed, will be away for a week, can be consulted and a formal decision from him obtained? In order to make any trustworthy decision it will be necessary for him to do what was done by us in our conference. Granting that he is a competent boss, he could scarcely render a decision which would be at variance with our findings. Since an adequate decision has already been dictated by the facts, my disposition is to proceed with the job at once. If we are right, the boss will endorse what we do, if his endorsement is requisite

or will do any good, and if we are wrong—well, we ought not to be wrong. Assuming that we understand our work, and, therefore, deserve to hold our jobs, we ought to be right."

The sales manager, the superintendent, the foreman, and the man who spoke of the propriety of waiting for the boss's decision did not remain silent. The points touched upon by them were pertinent enough, too, and if space permitted many of them would be worth repeating here. But irrespective of whether his views were sound or otherwise, what the engineer said indicated that he had thought of bosses, and of their relation to organic efficiency, in a more thorough and comprehensive fashion than had the others, and it is for that reason that I am featuring his comments.

"Much has been written about the elimination of waste," he said, after the debate had drifted to the beaten field of industrial efficiency. "The trouble with the experts on waste, it seems to me, is that they dwell almost exclusively on materials, whereas the biggest item of cost in industry is human waste, such as that suggested by the present incident. Coordination of effort is often referred to as an indispensable thing. But in practice isn't much of the benefit that should accrue from such effort lost? It certainly is if the effort must take the course that one man, sometimes without complete information, decrees must be taken. A great deal is heard nowadays

of group incentive and group efficiency, but how can there be group incentive or efficiency without group initiative and responsibility?

"The fact is," continued the engineer, "industrial management is still altogether too autocratic to be highly efficient. Consider the bees. As high-class industrialists they are worth considering. There is no boss in a bee hive, where, as the naturalists assure us, a higher degree of efficiency is attained than in any man-made institution. The queen bee, we are told, does her part with a proliferousness which is always adequate, but performs no other function; the drones are destroyed, not through an edict, but through the operation of an inexorable law of the hive, when they cease to serve a useful purpose, and are in the way, and the workers attend to their business of gathering and storing honey, unhampered save by the natural obstacles encountered in their journeys to and from the flowers. If the coördination of effort which is instinctive with these engineers of the insect world could be duplicated in industry, by man, there would come to him an increase of efficiency so great as to make the gains attributable to all the outstanding mechanical improvements of the age seem trivial.

"Nor is there anything in that to excite wonder. Treated as a coefficient, for calculating purposes, a human being may be multiplied by an infinitely greater number of factors than anything else in

animate form. In other words, man, functioning either alone or as part of an organization, has great adaptability."

The superintendent, a practical fellow with a sense of humor and a breezy style of expressing it, remarked that he knew little about bees except their sting, but that some of the human beings with whom he had to deal would, in his opinion, exert very little effort of any kind without someone about the premises to tell them what to do. "Bosses, therefore, are probably essential," he concluded, "despite the fact that many of them are more ornamental than useful."

"Of course they are essential," the engineer agreed. "I think it likely that you missed my point. Let me state it in more precise terms. As a convenient mechanism of skilled leadership, prerogative need not and ought not to be dispensed with, notwithstanding the fact that the bees do so well without it. The bees started to manufacture honey long before man knew anything about electric motors and generators. But however that may be, the weakness of boss rule in human industry is that it reaches so far, and is given so much weight, that it prevents a widespread, balanced, and effective use of human capabilities. Most industrial executives, big and little, are expected to do more, and heroically try to do more, than it is possible for them to do well. The distribution of a large share of their burdens among others would give added pep, and added power of service, to

the enterprises that they are running—for the most part acceptably, no doubt, with achievement measured by standards more or less antiquated."

These quoted comments, if printed when made, more than a decade ago, would have been classed as radical. They are not likely to shock anyone now, even the much maligned, hardboiled manager, who in the course of time has become humanized by contact with the individuals whose activities he is expected to guide, and made eclectic, forward-looking, and favorable to change by the wealth of information rendered available through research and experiment. There are, in fact, few leaders of industry who any longer doubt the wisdom of the widest possible participation in planning and managing activities as well as in benefits. Faith in the efficacy of group action, with both individual and group welfare as the goal, has become well-nigh universal.

And with that faith there have been innumerable applications of the employee representation or works council principle, some of them crudely conceived, with the forms of bargaining and other anachronisms retained, and, on that account, destined to fail wholly or in part. The applications that have had the largest share of success are those in which the interests of stockholders, management, and workers are not only alleged to be identical, but, with a due regard to normal relationships and equities, are treated as identical interests. One of them will now be described.

XXIV

Schenectady Works Council

AMONG the larger manufacturing concerns that have found contact with employees a weighty factor in promoting efficiency, the General Electric Company, with its working force that sometimes reaches 80,000 men and women, is conspicuous. That corporation now has Works at more than fifty points throughout the United States, a dozen of them being of sufficient magnitude to be classed as outstanding community features. Most of these major manufacturing plants have employee representation, the form varying somewhat to suit local conditions.

The form developed at the huge plant at Schenectady, and widely known as the Schenectady plan, is in some respects unique. I have described it elsewhere in these words: "Structurally it is loose-jointed and flexible, and it functions with so little of the ritual, and so few of the conventional trappings, of a plan, that to call it one seems paradoxical. Topsy's description of herself as a growth fits it quite well, although its origin is not so obscure as was Topsy's." When drawing that comparison, I was thinking of the plan not as one ordinarily thinks of a plan, but rather as an outcome of spontaneous group

thought and of collaboration to provide for a mutual need when the need was felt. And that's precisely what it is.

"What do we, as employees, want?" asked a machinist at a conference of a group of employees and the manager.

"Good wages and agreeable working conditions," said a pattern maker, " or at least a chance to confer about them."

"And a chance to confer is precisely what I want," said the manager—"an opportunity to meet and talk with you men, so that I may know how to be of help to you, and you may know how to be of help to me, and you and I may know how best to fill our jobs with advantage to ourselves and to others. I have no program; let us begin here and now to make one."

But a beginning had already been made with those simple declarations of a common wish; and within a few months there came into existence an organization called the "Works Council," consisting of three men representing the management, and about one hundred and fifty representing more than sixteen thousand workers.

This particular Works Council has no constitution and by-laws, and no rules of procedure except a few elementary ones needed to insure an orderly discussion and appraisal of facts. A small sub-committee, the membership of which is periodically changed, classifies subjects proposed for action and

selects those that seem to be the most vital. The selected subjects serve the purpose of tentative agenda by means of which time is conserved and debate made orderly and fruitful, but discussion is not necessarily confined to them. Two or more employees may cause any subject to be brought before the Council for an examination of its merits.

A distinctly useful purpose of another kind is served by the preliminary work of classification and selection referred to. The members of the sub-committee know from day to day what their shopmates are thinking of, and the first-hand analysis which, on that account, they are able to make in their own way, while throwing light upon the cause of a real grievance, and possibly revealing a means of redress, is likely to prevent the growth of a merely fancied grievance. Such timely analysis may be likened to the preventive measures that physicians advocate to preserve health. With the ups and downs of business that occasion irregularity of employment, and the normal readjustments, including improvement of methods, that are a part of normal progress, or are forced by competition, it is not always so easy to foster good will as to talk about it, but preventing the growth of ill will based upon misunderstanding is a clear gain for both management and employees.

It is noteworthy that the forestalling of misunderstanding is one of the most valuable things accomplished at the meetings of the Council. These meet-

ings have little of the atmosphere of a law court, since action on grievances is rarely called for. With a free and frank exchange of views, the diversity of which at times is itself interesting, relative to administrative methods, shop procedure, working conditions, and earnings, there is a tacit recognition of the will to be fair, and, as a consequence, the work of the Council takes rather the form of instituting improvements for the common good than of redressing grievances. The causes of grievances disappear, unnoticed, in the process of adjusting and harmonizing details, or, as a foreman once expressed the thought, "gearing business requirements to human capabilities and needs."

Many discerning managers who have not yet tried employee representation are familiar with this process, but few have discovered how to salvage and make use of its benefits. Much knowledge on that point has been revealed through the Schenectady experiment.

Experiment? Perhaps that word ought not to have been used, since it may be misleading. While the Schenectady Works Council has had some of the aspects of an experimental project, it has functioned concretely, not, however, as an arm of management, but rather as a unifying force between men and management, drawing from each something good and giving to both something better. Without au-

thority to determine policies, it helps to make them consistent, valid, and widely understood.

"Before the Council existed," said one of its members recently, "employees were usually in the dark as to the fluctuating character of orders. Lay-offs were made without explanation, or at least without adequate explanation, to those affected, because, with traditional shortsightedness, the state of business was looked upon exclusively as an affair of management. Partly because of the consequent lack of knowledge concerning the necessity of lay-offs, and partly because of the sporadic character of most of them, production had to be carried on much of the time in an atmosphere of suspense and suspicion. There was suspicion of favoritism, of hostility to labor unions, of sinister motives of all kinds. Now ample information bearing upon conditions affecting employment is always available. The management imparts it to the Council, and the Council members relay it to the groups of workers that they represent.

"As a result of this practice of making primary facts known, so that their purport may readily be seen, measures for mitigating the evil of interrupted employment are proposed from time to time through the Council, and some are adopted.

"Application of the idea of rotation of employment, for example, has been greatly extended When there is not enough work to keep a group occupied full time, an equitable allotment of the work in hand

is made to the members of the group. As a consequence of this spreading of the effects of temporary slackness, hardship has been alleviated and morale strengthened. Turnover, too, has been diminished, and one large item of indirect cost thereby reduced.

"Steadiness of employment has also been promoted to some extent through increased effort to determine the probable volume of orders for long periods, with the object of making rates of production for such periods as uniform as practicable."

"And there is no conscious altruism in such provisions," remarked a Works official who has had much to do with the Council; "they are welcomed by us with a sense of relief as one welcomes the solution of a knotty problem. We see in them an essential link that has long been missing, the link that connects human well-being with desired economic ends"

That comment explains how and why the Schenectady Works Council functions usefully without a constitution. The conviction is more and more taking hold of human beings that what they most need in order to act intelligently, which, of course, is to act for their mutual advantage, is information that will serve as the basis of action rather than set-ups to govern it; and the Council, which is both a melting pot and vehicle of information, supplies that primary need with the effectiveness of an automatic tool

The familiar framework of management does not seem to have been altered in any of its vital parts by this new industrial contrivance, but the need of jockeying, four-flushing, and sparring for position, if they have ever really been needed, has been wholly done away with. The study of facts and of their relationships has been found to be more fruitful, so far as efficient production goes, and so far as tangible gains for labor go, than the time-honored practice of dickering.

Substitution of study for controversy has also had the effect of quickening popular interest in welfare provisions of a general character instituted in the past. For some time a clear perception of the purpose of such provisions was lacking, and on that account their effect, so far as the promotion of esprit de corps went, was not proportional to their merit. Some of them had no aspect of realism for the average employee with duties remote from administrative routine, and untrained to think of his work except for what it yielded him from week to week. At least they were so distant and hazy to him that he was not able to tell his wife, for example, what they meant for her. Many a widow has had the surprise of her life when tendered a check for $1500, due her, upon the death of her husband, under the free life insurance plan inaugurated a number of years ago. As is well known, there is now in effect a supplementary insurance plan under which insurance additional to

that which they have without cost is available to employees at less than normal premiums.

An uncounted blessing, too, in more than a few instances, has been the pension plan, in effect since 1912, under which a man at 70 or a woman at 65, with a period of service of 20 years or more, is enabled to retire with a monthly payment substantial enough, when combined with moderate savings, to insure independence.

Two important provisions, by the way, were added to the pension plan, in 1928, one for conditional retirement at 65 in the case of a man and at 60 in the case of a woman, the other for regular savings by employees.

These plans, and others of like nature which have long been in operation or are now in course of development, are at present widely discussed because of the consideration given to them from time to time by the Council; and not only is the discussion informative, but out of it come suggestions that help the management to link welfare activity with operating procedure so that one gives effectiveness to the other.

A recent incident illustrates the quickening of popular interest in things affecting employees which has been mentioned as coming from increased contact. Located at the center of the Schenectady Works is a dispensary with a physician, a staff of assistants and nurses, and much of the paraphernalia of a modern hospital. Originally intended as a

readily accessible first-aid station, its equipment is now such that many classes of acute ailments and all minor injuries have skillful treatment there.

"I have heard much favorable comment about the service rendered by the dispensary," said an employee after listening to a review of its work at a Council meeting," but our people sometimes have to go to the local hospital, and I would like to learn if they get as good treatment there as they do at the dispensary. I suggest the appointment of a committee to visit the hospital and make a suitable investigation."

The proposed action was at once taken, and the report of the investigating committee showed that in its judgment, apart from an insufficient number of orderlies, the conditions at the hospital were as good as could reasonably be expected. Additional orderlies were afterwards provided at the hospital, but what is mainly significant is that such an investigation was thought of and made.

"What classes of subjects are discussed by the Council?" asked the manager of a public service corporation who, a short time ago, visited the Schenectady Works to inspect a generator which he had ordered, and who expressed special interest in employee representation. He was told that no subjects were excluded, but that the Council itself, with the aid of its programme committee, gave priority of attention to those of the greatest moment

to the largest number of employees. "Well," was his final comment, "the thing of major importance is the contact you have established."

Efficiency engineers have long been making exhaustive studies of procedures and mechanisms without weighting the human element. To this incompleteness of treatment may doubtless be traced the reason why so many of their reports are unread and so much of their work is futile. Practical managers themselves are nowadays more and more seeing in mere contact the primary means of eliminating lost motion and waste, although some of them are slow to accept the idea that in order to insure contact simpler formulas and concepts must replace those to which they have been accustomed. The idea of contact for mutual advantage seems to have been the controlling one in the development of the Schenectady plan of employee representation, and is the one that makes the plan workable.

A word as to the main objection that has been made to Works Councils is in order here. These organizations are sometimes referred to, partly in a tone of satire, as "Company Unions." The term is, of course, meant to imply ironclad corporate control with the introduction of a democratic gesture to give the control an engaging aspect.

So far as administrative mechanism goes it would be quite disingenuous to assert that with Works Councils corporate control is done away with or even

lessened. It would also be misleading. As industry is now organized any other kind of control than corporate control, or the control that is inherent in ownership, would be impracticable.

But is the question of control, in a technical sense, germane? It scarcely seems so, except from the point of view of one contemplating a fundamental change in our industrial system. Most of those who characterize Works Councils as "Company Unions" contemplate no such change, so there is evidently a breach between their premises and their logic.

The Councils have never been represented as having a revolutionary purpose. They are rather agents of conciliation, understanding, and agreement. Wisely run, their effect is to improve the quality of control, with advantage to all concerned. If a democratic gesture is all that is novel in them, it must be admitted that they are bound to be a fizzle.

XXV

Measuring Men

Large corporations have long given attention, in one form or another, to the classification or rating of employees. The General Electric Company some time ago made an exhaustive study of the subject. Without respect to the lines which that study took, or the plans that it led to, I wrote an article in which were embodied my views concerning the selection of men to fill major executive jobs in industry This article was published in the General Electric Review. It is reprinted below because of the interest which it aroused in anthropology as related to industrial management.

MOST of the discussions about keeping an organization well manned, so that its vigor and efficiency will not diminish with time, cover a limited field. They do not extend to men filling positions of higher rank than that of a foreman, namely, to superintendents, department heads, and managers.

"What should be the qualifications of a foreman?" is an oft-repeated question, and so far as it goes is a pertinent one. The question, "What should be the qualifications of a manager?" however, is rarely asked, at least openly. Perhaps it serves often enough as a topic of private conversation among employees filling subordinate positions; but conclusions arrived at in conversation of that character lack practical value since they cannot be examined, in any definite and concrete form, by men broadly responsible for ad-

ministrative routine and concerned with the building up of an efficient personnel.

That foremen need to be well equipped for the work they have to do may be taken for granted. Their cumulative power for good or evil, in an economic sense, is beyond computation. In considering individual jobs and the qualifications of employees assigned to them, however, range of influence must be dealt with as a primary factor. While it is important that foremen be capable, it is more important that the men of higher rank be so, because the effect of what they do, and what they are, has a wider spread. A misfit in a minor job muddles things at one point. In a big job he can wreck an enterprise.

Let us assume that a foreman, a superintendent, a department head, and a manager, should possess certain qualifications in common, such as personality, knowledge, experience, and physical energy. There are other qualifications, however, which are not indispensable for foremen, and those performing different classes of supervisory service under foremen, but which are indispensable for a manager or anyone who gives direction, color, and character to the work of a large number of employees with diversified tasks.

A foreman who, for example, has charge of a machine shop with 50 workers performing repetition labor, may be said to be a high-class foreman, and may, in time, become fitted for a managership if, among the other qualifications that his job as a

foreman demands, he has what is known as imagination. The work that he supervises will not suffer seriously, however, or for a long period, if he does not have imagination in large measure. The feature of safety in his case is that his area of influence is limited and that if he is not wholly fitted for the job which for the time being is his, he may readily be shifted to another for which he is better fitted, or his services may be dispensed with.

A manager, on the other hand, who supervises the work of a thousand, ten thousand, or twenty thousand employees, must be richly endowed with imagination, in addition to having the qualifications expected of him in common with a foreman. Otherwise, the work that he is chosen to do, even though it may seem satisfactory to a casual observer, is not likely to be done efficiently. In his case limited knowledge and experience will be less hurtful, economically, than a deficient imagination. And, moreover, if he is a misfit, there are usually many reasons why his replacement and assignment to duties of a different character cannot readily be effected.

Now, what is meant by imagination? Almost anyone will at once see that it is the outstanding qualification of an artist, a dramatist, an inventor, or anyone else whose work is creative. So far as it relates to administrative or supervisory duties in industry, imagination may be defined as the power to under-

stand what is not obvious, to balance and coördinate a great variety of factors, some of which may be obscure and call for research, to see ahead, as well as on both sides and behind, but particularly to see ahead and to make plans for next month's or next year's work. One of its indications, also, is a readiness to entertain and to try new ideas.

So far as imagination is concerned, a manager therefore should be classed with an artist, a dramatist, and an inventor. If he cannot feel at ease in that kind of company he is not likely to function well as a manager. That does not mean that he must be able to produce pictures or plays, or even to invent labor-saving devices, but rather that he must have, among other things, the vision and power of coordination that such work calls for.

Seven basic qualifications of a manager or anyone in line for a managership are given below in what seems to be the order of their importance:

(1) Intellectual honesty
(2) Imagination
(3) Judgment
(4) Personality
(5) Knowledge
(6) Experience
(7) Physical energy

Though not heretofore mentioned, intellectual honesty takes its place, naturally, as an assumed

qualification at the head of this list for anyone who is to be appraised for a managership. No one whose mental processes are crooked instead of straight, however able he may be, can get far in a managerial or supervisory job—much further, in fact, than his title carries him, which is not very far. Those under him will take care of that point if those above him overlook it. Judgment may be classed with imagination, but is listed as a distinct basic qualification in order to emphasize the fact that a manager must have decision, when it is called for, and be a doer as well as a seer.

A study of men holding jobs as managers, department heads, and superintendents, and of those who are being trained to fill such jobs in the future, may be made with advantage by determining their relative strength in the qualifications mentioned. This relative strength may be stated in percentages, letting 100 per cent stand for par.

Percentages for three assumed cases are listed in Table 1 to indicate how comparisons, employed as an aid in the fitting of men to jobs and jobs to men, may readily be made after obtaining reliable and adequate information regarding the qualifications of different individuals. How such information may be made available will be suggested as this analysis is developed.

TABLE I

Qualifications in Order of Importance	Case A Par 100%	Case B 100%	Case C 100%
(1) Intellectual honesty	100	100	100
(2) Imagination	95	70	40
(3) Judgment	85	85	75
(4) Personality	90	90	70
(5) Knowledge	80	85	90
(6) Experience	75	80	90
(7) Physical Energy	65	80	97

Intellectual honesty is given 100 per cent in all three cases, for it must be taken for granted that anyone who falls short of par in that qualification should not be considered at all for any kind of a managership, since he is bound to be a failure. Workers will often do their best for a leader with some of the attributes of a blockhead, if he is square with the light that he has, but withhold loyalty from one who is shifty, even if brilliant; and of course organic efficiency is never possible without a loyal spirit. The variation in the other six qualifications is normal, and in the study of actual cases it is necessary only to determine the degrees of variation.

Before any weighting of qualifications is attempted, it will be helpful to make a mere surface analysis of the three cases mentioned, with the object of determining offhand their relative fitness for managerial jobs.

Case A would doubtless make the best manager of the three. He is high in imagination, very good in judgment and personality, good in knowledge, fair in experience, and passable in physical energy. While physical energy may be a most important qualification in a foreman or assistant foreman, it seems to be the least important in a manager, since it is not so essential that the manager himself be physically energetic as that the many others whom his imagination influences shall be so. His individual labor, so to speak, cannot be very much greater in volume than that of any one worker in a force of a thousand, but the volume of his induced labor, or that performed by others under his inspiration, must be very great. Cases of highly capable individual workers with little or no skill, however, to bring out the best there is in others, will readily occur to any observer, since they are numerous in most organizations. What such workers are likely to do, when invested with much power, is to keep organic efficiency low without any intention or consciousness of doing so.

Case B would be a fairly efficient manager because, although he has less imagination that Case A, his average in the other qualifications is somewhat higher. The differences in his favor in knowledge, experience, and physical energy are not enough to balance the difference against him in imagination. In trying to determine the rating of particular individuals through an analysis of the different qualifi-

cations listed, these qualifications must be weighted, as has been already intimated, and in a weighted tabulation relating to a manager, by far the highest number of points ought to be given to imagination. A tabulation with a scale of assumed weights that seem reasonable will be given later.

Case C would be rather mediocre as a manager, because his imagination is poor, only 40 per cent, and his judgment moderate, 75 per cent, but since he is high in knowledge, experience, and physical energy, and particularly high in physical energy, he would be able to render useful service in a subordinate capacity where he could be guided by the imagination of Case A or Case B. Given very much authority, and left to himself, his low imagination and high physical energy would be the cause of many costly blunders. A superabundance of physical energy with little imagination leads to lost motion and duplication of effort, sometimes with belated action on vital matters.

In applying the information obtained by a study such as that described, a pension system might be made use of in the shifting of men or in retiring them prior to the eligible age of retirement. The main purpose of a pension system, however, is to make provision for old age, and many exceptions to the rules that govern the granting of pensions might defeat that purpose. The fitting of men to jobs and of jobs

to men is a distinct problem. Linking it with questions of age, period of service, and pensions might therefore lead to confusion, as well as to abuse and ill will.

Some confusion from this cause may now exist. When, for example, an employee is seen to lack initiative at 55, 60, or 65, the condition is ascribed to advancing age, whereas an analysis might show that he lacked initiative at 30 or 35, that he was not properly fitted to his job at that time and has ever since worked under difficulties, with disadvantage to himself and to his organization. While old age, with its infirmities, is at some period inevitable, mere statistics relating to it have to be used with much discrimination. Some employees between the ages of 50 and 70 keep in good physical condition and preserve a youthful spirit. Their experience is a valuable asset and may be made use of fully through a plan under which human capabilities would be appraised and classified.

The development of such a plan should not be difficult—not more difficult than the development of a system for the classification and appraisal of tools used in production. Employees reveal their qualifications through what they do and the way in which they do it; but it has not been customary to catalogue and index the qualifications of a manager and to determine their relative influence on efficiency with the object of making suitable selections for jobs. It seems reasonable to assume that the quality of ad-

ministrative work could be improved through its treatment in some such scientific way as that outlined. To be sure, a human being, regarded as a mechanism, has more variables than other mechanisms, but thoroughgoing study should lead to any necessary or useful factoring of these variables. It should be remembered that the qualifications listed are basic ones, and that measurements applying to them would have to be modified by collateral qualifications, or the lack of them, as well as by facts as to age, health, and temperament.

An associate with whom the writer discussed this subject of fitting men to jobs suggested that executive ability be classed as a basic qualification. For the purpose of this analysis, however, it is not so classed because such ability is the result of a coördination of the qualifications mentioned. Treating it as a distinct qualification probably leads to many misfits in management. Executive ability, for example, is popularly associated with physical energy, and as a consequence a physically energetic man, or one whose motions are rapid and vigorous, is readily chosen for a job for which he is not wholly fitted because of low or mediocre imagination. In practice, it is much easier to err through the misplacing of physically energetic men than through the misplacing of those of high imagination. A man who is high in imagination, but very low in physical energy, as well as in the other qualifications, is likely to be appraised as a day-

dreamer, and on that account definite responsibilities are not readily assigned to him. He is left to work in the way in which he can best work.

To state the case in another way, there is an automatic check on the mischief that a mere daydreamer may do; whereas a man with marked physical energy, particularly if it is combined with an engaging personality, but with very little imagination, knowledge, and experience, can do irreparable damage before his limitations are gauged.

The writer recalls a dialogue which he once heard between two employees concerning their superior. "He is dynamic, but lacks vision," said the first employee. "Yes," said the other, "he certainly qualifies on dynamics, but it is a pity that he is not made chief of the yard gang where he could do justice to himself and be of service to the organization." This case was one of an apparent misfit in a managerial job.

In Tables II, III, and IV, the three cases that have been described are analyzed to determine the fitness of each for a managerial job through a weighting of their qualifications. The rating percentages established earlier for the different classifications in each case are retained; and 10,000 points, fixed as unity, are apportioned to the qualifications according to the importance of the latter.

TABLE II

CASE A

Qualifications	Weight Units Par 100	x	Rating Per Cent 100		Total Points =10,000
Intellectual honesty	(Indispensable, therefore not weighted)				
Imagination	35	x	95	=	3325
Judgment	18	x	85	=	1530
Personality	17	x	90	=	1530
Knowledge	13	x	80	=	1040
Experience	12	x	75	=	900
Physical Energy	5	x	65	=	325
					8650
Per cent of Par					86½

TABLE III

CASE B

Qualifications	Weight Units Par 100	x	Rating Per Cent 100		Total Points =10,000
Intellectual honesty	(Indispensable, therefore not weighted)				
Imagination	35	x	70	=	2450
Judgment	18	x	85	=	1530
Personality	17	x	90	=	1530
Knowledge	13	x	85	=	1105
Experience	12	x	80	=	960
Physical Energy	5	x	80	=	400
					7975
Per cent of Par					79¾

TABLE IV
CASE C

Qualifications	Weight Units Par 100	x	Rating Per Cent 100		Total Points =10,000
Intellectual honesty	(Indispensable, therefore not weighted)				
Imagination.	35	x	40	=	1400
Judgment..	18	x	75	=	1350
Personality.......	17	x	70	=	1190
Knowledge..	13	x	90	=	1170
Experience.	12	x	90	=	1080
Physical Energy	5	x	97	=	485
					6675
Per cent of Par..					66¾

It is easy to see that in dealing with actual cases differences of opinion may develop as to ratings and as to the apportionment of weight units to the different qualifications. Some may think that physical energy, for example, should be ranked higher than seventh and given a greater number of weight points than five, and they may be right. The tabulations are but one expression of judgment concerning the relative influence upon organic efficiency of qualifications required in a manager as distinct from men filling other positions. All of the qualifications mentioned are essential. Placing physical energy at the bottom of the list and giving it the fewest weight units may be questioned. No disparagement of that praiseworthy qualification is intended. The fact that

Case A is only passable in physical energy unquestionably limits his value in some measure. With imagination of 95 per cent and judgment of 85 per cent, he would be better off with physical energy of 80 or 90 per cent instead of 65. Case C however is different. With rather low imagination and only passable judgment, his physical energy of 97 per cent would make him a positive menace in a managerial job. Teamwork being the outstanding requirement of an industrial organization, the individual hustler has a mission there only as he works constructively with others and is as eager to promote their efficiency as his own.

The primary purpose of the present analysis is to illustrate the practicability of predicting managerial capacity through the determination and appraisal of essential qualifications. The problem of personnel is receiving widespread attention, and will be solved largely through the selection of capable managers, because the men at the top give an organization its tone, and are the measure of its capacity for service.

XXVI

Steinmetz On The Workday

WHEN Steinmetz was spoken of as an asset salvaged from the wreckage incident to the panic of 1893, it was said that he would inevitably reappear in this history. From time to time there came from him, usually through interviews, comments which were, so to speak, but parts of his mental process, but which, on account of his reputation as a wizard, took on the aspect of pronunciamentos. Several of them attracted widespread attention and occasioned much controversy, some of it heated. His reference to a four-hour day, for example, startled the continent, and, because it was generally misinterpreted, caused a run of distressing nightmares among touchy, jumpy, and unimaginative employers of labor. The misinterpretation was apparent to me because I had several times talked with him on the subject before and after the distorted versions of his idea appeared in print. He really never intended to advocate a reduction of the workday, under existing conditions, to four hours. So far as I know he never specifically advocated any reduction. The expression "four-hour day" was employed by him in a hypothetical sense, as an aid to thought, his aim being to indicate that under other

conditions, that is, with the extended use of mechanical power in industry, a workday as short as four hours would become practicable.

Steinmetz, it may be added, was temperamentally unfitted to take sides, in any dogmatic way, on any issue. He shrank from controversy of a militant character, and when he saw it impending, retreated, often unobserved, to his laboratory or some other convenient place of refuge. He was essentially an idealist who saw, in the distance, goals that he thought mankind would in time reach, not through conflict, verbal or sanguinary, but through increased knowledge and intelligence. Even his socialism, at least the larger part of it, was of the brand which is readily accepted, under other names, by most of the dwellers on Main Street.

I well remember the occasion upon which I first heard him speak of a four-hour day, and in view of the interest that inheres in anything that throws light upon his personal characteristics, I now think it fitting briefly to describe that occasion itself.

Arriving at his camp on the Mohawk river one Saturday afternoon in early summer, I found him attired in a bathing suit ready to go out in his canoe. "Come with me," he said graciously, and I eagerly accepted the invitation.

As we reached the middle of a shallow bay, a stone's throw from our point of embarkation, I noticed that his expression was furtive and his style

of paddling somewhat erratic. I had heard that Steinmetz occasionally entertained his guests with water "accidents," and suspected that he was so manoeuvering his frail craft as to cause one. My suspicion was fully justified, for presently an "accident" happened; the canoe capsized and we landed in the water, the depth of which was not more than two or three feet.

"We may swim or wade to our destination," he shouted. "Quite right," I replied with assumed nonchalance. My exit from the canoe had been a sidewise one, but I had agilely assumed an upright position so that the surface of the water was above my waist. I was too heavily accoutered to swim with comfort, so, pushing the boat ahead of us, we waded a distance of some fifty feet to a small island. On this island, near the spot where we landed, was a small covered box from which my host withdrew a light blanket.

"We keep this here," he said, handing the blanket to me, "so that a marooned guest who has been in the water in street attire, may not be subjected to prolonged discomfort. Maybe you would like to strip and put it on. The boys at the camp witnessed our plight, and one of them is already on his way to your home for dry clothing."

As I had been completely submerged, I was glad to adopt his suggestion. "You have proved to be a very satisfactory subject," he chuckled. "Occasion-

ally when I lose control of the canoe with a guest in it, the guest contrives to go out of the boat vertically, feet downward, and then the boys, all strong believers in total immersion, and expecting what is known in their lingo as a lateral splash, berate me for my lack of skill. You see the young rascals will have no cause for criticism in the present case."

The references to "the boys" in the quoted language will at once remind those to whom Steinmetz was personally known, of one of his idiosyncrasies, but, without an explanatory comment, are likely to be vague to others. Youth had for him an extraordinary attraction, and throughout the most active period of his life he kept at his camp, in his study, and about his laboratory, as he played, or thought, or worked, a retinue of young men, many of them under twenty. Their antics amused the impressionable scientist, and he was stimulated by the originality, vigor, and wholesomeness of their ideas concerning the elemental things in which he was interested. They, in turn, were vastly benefited through their contact with him, for he was a born teacher, for whom it was literally a "joy forever" to impart what he knew to receptive minds.

The island on which we landed was a comfortable place, so we remained there for nearly three hours talking about industrial conditions. The problems of his profession, electrical engineering, were often discussed by Steinmetz, to the exclusion of other

problems, with most of the men with whom, at the time, he was more or less intimate, but, during my visits with him, were rarely mentioned by either of us. I was not very familiar with electrical engineering, particularly the theoretical side of it, and on that account was usually reluctant to introduce the theme. On the other hand, Steinmetz was prone to encourage his guests to introduce topics of conversation. Many topics not pertaining to his profession were congenial to him and he entered into their discussion with zest.

"It seems likely that the eight-hour day will soon be universal in this country," I said, recalling an article on the subject in the morning's newspaper. "It is hard for me to account for the vast volume of agitation which was required to bring it about, for I thought the demand for it reasonable, that is to say, some shortening of the workday struck me as economically safe and even desirable."

"Much of the agitation that you speak of was a jumble of words, and that in turn, was a consequence of wrong methods of approach to the issue," answered my companion. "The question of how long the workday ought to be is not a question of principle, as capital and labor have, from time immemorial, assumed, but rather is a question of expediency. We work in order that we may have food, shelter, and other so-called creature comforts; we do not have these comforts in order that we may work. The work that we do to get them is necessary in order that we

may have them; thus it is enforced work. Now, we try in a variety of ways to make enforced work agreeable, and are often successful, but it is inherently disagreeable, and consequently our aim should be to lessen its amount. To the extent that we lessen the amount of enforced or disagreeable work, to that extent we increase the available time to do work which is voluntary and agreeable. So, with you, I view with satisfaction the reduction, finally, of the workday to eight hours. I hope that, through mechanical invention, we shall be able, even in the present generation, to reduce it to a much greater extent. Considering the rate at which machine production is superseding production by human muscle, it is quite logical for one to look forward to a workday of seven hours, of six, five, and even four."

"If I may interrupt you with a feeble pun," I said, "a four-hour day strikes me as very much of a day-dream."

"At present, to be sure, it is no more than a dream," Steinmetz granted, "but while dreams ordinarily receive no recognition in my calling, the fact is that some of them come true. I have a hunch that it would be a good thing for science if it were a little more chummy with dreams than it is. Dreams are but a form of imagination, and without imagination, science would be nothing more than a set of formulas. Unfortunately it is often nothing more than that now. I read fairy tales, not only because many of them are

competent literature but because more than a few are packed with wisdom of a practical nature not to be found in scientific tomes."

"Before we can make the dream of a four-hour day come true," he added with a sigh, "we must, of course, learn how to distribute the fruits of machine production. From the point of view of society as a whole, you see, we are much farther advanced with production than we are with distribution. One is scientific, or measurably so, the other wholly unscientific. We coöperate, both voluntarily and under compulsion, to produce, and because we coöperate, we become more and more efficient as producers. In our method of distribution, on the other hand, we are but a few stages ahead of the cave men. In effect we have no method of distribution; what we have is a scramble for dollars, or other certificates of material value, in which a certain form of cleverness, not in itself a particularly admirable form, has a marked advantage."

"But perhaps it behooves one to speak gingerly of that point," he reflected after a moment's pause, "for those who, through cleverness, emerge from the scramble with its prizes, think that the scramble, as such, is a good thing, and not only do not wish it replaced by anything better, but cannot conceive of anything better."

The connection which Steinmetz appeared clearly to see between the fruits of efficient production and a

shortening of the workday, was not obvious to me so I questioned him specifically concerning it.

"I have no bias against riches, and, above all, against rich men," he explained. "I just think there is no gain in the use of accumulated wealth merely to produce more and more wealth to be scrambled for. In fact we do not have to look very far beyond our noses to see in it a positive danger, for it makes our social and industrial structure lopsided. To produce wealth with ever increasing efficiency is, of course, altogether rational, provided we do it with a valid object; but the only object that appeals to me as valid is a reduction of our enforced work, that is to say, the work which it is necessary for us to do in order that we may have creature comforts, and, in turn, in order that there may be increased opportunity for work of a creative, pleasurable, and cultural character. With that object in view a continuous shortening of the workday should be automatic rather than an outcome of agitation. In other words, it should be a normal result of increased productive efficiency."

"Must not any cutting of the workday," I asked, "properly be considered in connection with standard of living? A gradually improved standard of living may be generally acceptable in lieu of a gradual shortening of the workday; and, of course, in recent years we actually have had steady improvement of the standard of living. An increase of labor earnings

is, to be sure, a prerequisite of an improved standard of living, but can we have both an improved standard of living, with its prerequisite of an increase of labor earnings, and a shorter workday? Can we have our cake and eat it?"

"Our discussion seems to be taking a trend toward territory usually classed as dangerous," said my host absently, his thoughts momentarily diverted by an ant carrying an object several times its own weight.

"Your argument is in some respects specious," he added, after the ant had landed its burden, "hence I fear it would be more or less muddling to a mixed audience. We really can eat as much of our cake as we have appetite for and have a lot of it left. Your implication that the amount of cake available is limited bears a striking resemblance to the Malthusian plea for a check upon propagation to conserve means of subsistence and keep the race from starving. What Malthus failed to anticipate was that while man would continue to be as prolific a breeder as nature meant him to be, the brain that distinguishes him from all other animals would enable him to provide means of subsistence faster than he could breed. Birth control may be desirable for some reasons, but not for the reason given by Malthus.

"Whatever the length of the workday, whether it be eight hours, ten, or four, the earnings of labor, it must be assumed, should be adequate; but a shortening of the workday must be one of the consequences

of increased productive efficiency, brought about by the introduction of machinery and improved methods, if the increased efficiency is to have permanent social value. An increase of leisure for creative and cultural activity is, in other words, the main element of an improved living standard. The other elements are doubtless all to the good, but they have no direct bearing upon my contention. Their economic equivalent is part of the cost of production, a wholesale lessening of which, through the application of mechanical power, is my premise.

"Reasonable profit for capital is not inconsistent with my contention either. Capital is an inherent part of our present industrial system, and, therefore, it should have its just due, whatever that may be, before a shortening of the workday, to give increased leisure, is warranted. Production for individual profit may be, as some think it is, a survival from barbarism and economically as well as morally absurd, but until superseded by a form of production better suited to society's requirements now, it must be a factor of any calculations as to the length of the workday."

"It strikes me that you are ignoring the important question of incentive," I said, passing to another phase of the subject. "Indolence, you know, is not an uncommon human trait. If anything were done to make the accumulation of surplus wealth, by an individual, less desirable than it is, would not the effect be to lessen individual initiative and pep, to

which so much of our material progress is traceable? Furthermore, so far as men and women in the mass are concerned, is there any assurance that the increased leisure that would come to them through diminution of necessary work, or, as you call it, enforced work, would be advantageously employed? Would not its effect be to crowd the highways and byways with idlers?"

I remarked a few moments ago that Steinmetz shrank from controversy, but I then had in mind controversy of the conventional sort, relating to creeds, social customs, and the mere forms of business. He was a ready and forceful debater when debate seemed to him worth while, and moreover to debate with him was satisfactory because he welcomed dissent from his conclusions. Dissent seemed to him of value as a check upon the correctness of the conclusions. His fingers played havoc with his hair, which normally had a more or less disheveled appearance, as I spoke of incentive. I fancied that I had given him a hard nut to crack, but his rejoinder was plausible.

"Your point is a familiar one," he said dryly. "It is featured in most books of homilies. Of course, incentive is important, very important, but let us examine its nature and see how it operates. Human beings display diligence and enthusiasm when striving for material gain, but is not that due rather to themselves than to what they strive for? Diligence and

enthusiasm are common in the pursuit of many things. They are displayed by the scientist, whose thoughts are rarely fixed upon the commercial value of the knowledge that he seeks, by the poet who is unfitted to hawk his visions, even if they have a market value, by the artisan who prizes his handiwork chiefly because of its excellence, by the housekeeper who wants her home to be clean and tidy because dirt and disorder make her unhappy, and by countless others. At times incentive to effort is disproportionately powerful, that is, the worth of the object sought does not appear to justify the strength of the incentive. During the Middle Ages, for example, hundreds of thousands of pilgrims underwent incredible hardships, many of them perishing, through a desire to obtain possession of a distant city which in itself had nothing of a substantial character to give them. They were stirred by an idea, the impelling force of which is not wholly intelligible to moderns.

"The question of incentive really has many aspects but what I mainly contend is that material acquisition and incentive are not at all analogous to the famous Siamese twins. Incentive is linked rather to imagination, which is common among human beings, irrespective of their pursuits. Thus, it may safely be assumed that an increase of leisure would not be followed by an increase of idlers. It would doubtless result in altering some of the present forms of human

activity and, perhaps, in the development of some new forms, but that would be all to the good."

Steinmetz was thought by many to be less sound on economics than on engineering. Perhaps he was; perhaps he was not. I shall refrain from any discussion of that point, letting the views which he expressed to me on the length of the workday, during our sojourn on that miniature island, rest on their merit. I am but a chronicler.

XXVII

Captain Of Industry

As soon as we returned to the camp, on the occasion which has been described, Steinmetz started to do what he called one of his daily chores, namely, to prepare a simple dinner. When the cooking operations were well under way, and there was opportunity for further talk concerning the subject discussed on the island, I asked a question which led to a dialogue relating to large corporations. This dialogue, or rather Steinmetz's part of it, should be of interest. The substance of both parts will be given, but first a further word as to the temperament, or, to be more precise, the mentality, of my host is in order. He was not afflicted with inhibitions. Toward anything morbid he had the antipathy of a normal boy, but could walk through a country churchyard at the witching hour of night with no thought of spooks. His mind was habitually well poised, it took straight cuts to all problems within its range, and was not passionately concerned with others. A few private prejudices, having their roots in his early experience as a student and embryo revolutionist in Germany, gave spice to his spontaneous comments, but toward the fashionable prejudices he was just distantly civil, like a man of breeding toward a

mother-in-law; their influence upon him was virtually nil.

As a consequence, his opinions did not always have the appearance of consistency, or rather, of cohesiveness. They reminded no one of a row of bricks. Each of them was expressed with amplitude and sincerity, and apparently without effort to make it dovetail with the others. He understood human nature, and could mix with men of diverse tastes without discomfort, but had no use for guarded speech.

"Why should he employ the weasel words of a trimmer?" a zealous disciple of his once said. "There's nothing picayunish in his conceptions. It is altogether likely that what he says to-day on a given theme will be found, upon analysis, to be substantially in harmony with what he said yesterday on the same theme, for his trump card is logic, but nothing bores him more than a meticulous verbal matching of his utterances."

Maybe there's a tone of bias in those words, but they accurately portray Steinmetz and explain why he was sometimes misunderstood.

I shall now go on with my account of what was said while the meal of which I have spoken was in course of preparation, and later while justice was being done to it.

"Isn't the argument that you advanced in favor of a continuous shortening of the workday," I asked, "at variance with your well-known belief in the beneficent character of large corporate units, into whose hands the control of industry is rapidly passing?"

"Not at all, not at all," was the emphatic reply. "The large units that you speak of are beneficent, at least they seem so to me, although I would not go so far as to call them the be-all and end-all of industrial development. They have their shortcomings, which are due in part to human weakness, and in part to the fact that, because they are relatively new, there is not as yet a very clear general understanding of the ultimate effect of their work. Nevertheless, they have done more during the last fifty years to lessen the drudgery of life than was done for a thousand years before."

"There is still a lot of drudgery," I remarked. "Society's membership includes many drudges of one sort or another."

"There will be much less drudgery and fewer drudges when we learn the secret of efficient distribution of the fruits of efficient production," the scientist declared. "Moreover, while productive efficiency has increased at a rate that seems phenomenal, we do not appear to be even close to what engineers call the 'saturation' point. I predict that cost of production generally will be cut to a small fraction of its present

cost through applications yet to be made of the energy in nature already revealed to us. And there must of course be much energy still unrevealed."

"The most widely read of the world's famous books," he went on, "contains a statement to the effect that man shall earn his bread by the sweat of his brow. The statement was pat at the time it was written, and for ages afterward, but with the change of conditions wrought through the extended application of mechanical power by the large corporations, its qualification has become necessary. An infinitely greater quantity of bread is now earned through the whirl of machinery than through sweat of the human brow.

"I doubt not that perspiration has all the virtue, in a physiological sense, that it ever has had, but to associate it with the earning of bread seems no more apt than to associate travel with a stagecoach or a sailing vessel. Many of the heavier tasks of the farmer, even, who at all times and in all lands has sweat more profusely than any other worker, are being done away with through the replacement, on a vastly extended scale, of manpower by mechanical power in agriculture. The tiller of the soil is, in the last analysis, still the chief burden bearer of society; his lot remains an unenviable one; but he is appreciably better off than he was when Edwin Markham's vivid and stirring poem about him was first printed. And much of the arduous and unremitting

toil that for ages bent his back, benumbed his senses, and kept him from being anything but a clod, will presently be eliminated as a consequence of the work which is being done by the large corporations."

He cited other examples of the marked curtailment of drudgery which had been brought about from the time of his arrival in America.

"By attributing that consummation to the large corporations," I said, "you place them in a more favorable light than do even some of the men who speak officially in their behalf."

"Posterity," he replied, "giving to the large corporations exclusive credit for the coming of its six-hour, five-hour, or four-hour workday, will take off its hat to them, and marvel at our toleration of a vast multitude of small competing industrial units with their misdirected effort, throat-cutting procedures, and colossal waste. I believe in most forms of democracy, but the democracy that restricts concert of effort to secure increased leisure through a reduction of the cost of our material wants, is very much of a snare and delusion."

A few years ago a New York newspaper published the names of the foremost captains of industry in America, and that of Steinmetz was among them. It was not out of place there. So far as the economics of big business go, they were quite as well understood by him as they are by the most astute magnate who has ever engineered a merger, but he, of course,

thought of them in social rather than individual terms. In that respect he was different from most of the magnates with whose names his was printed. As a student and worker Steinmetz was distinctly an individualist, but he also was a sincere believer in the democratization of economic power as a means of promoting human welfare.

XXVIII

WHAT STEINMETZ DID

(Written shortly after the scientist's death)

THE question "What is genius?" has been discussed from many angles but never quite satisfactorily answered. Interest in it was revived by the death of Charles Proteus Steinmetz, whose experiments made to ascertain the effect of lighting on electric circuits caused millions to doubt if Jove had done anything wonderful.

Genius itself may not be so very rare. Practical folks define it as capacity for hard work. Steinmetz assuredly was a hard worker; but hard workers, useful and otherwise, are not uncommon. One thing, in any event, seems certain. Genius, as a rule, has a difficult time getting itself recognized before it has passed through a christening and labeling process, and, as it were, received a certificate of verity.

There are exceptions to that rule, as there are to most rules. The biography of Robert Burns tells how he might have died in obscurity in the West Indies, if plans which he had made to go there, before many of his imperishable lines were composed, had not been abandoned at the final moment in consequence of the receipt of an appreciative letter from a clergyman in Edinburgh. The name of the clergyman

CHARLES P STEINMETZ

was Blacklock. He was a man of note in his day, zealous and useful in his calling, and a discriminating judge of literature, but the incident of his life that made the most enduring impression was the writing of that letter, which was afterward believed to have rescued from oblivion the author of "Auld Lang Syne."

As was doubtless true of the Scotch plowman, with his gift of expression, Steinmetz may have contrived, in any circumstances, to make the marvelous intellect with which nature had endowed him of some service to mankind. It is at least possible that he would not have had the opportunity to do so, in the fullest measure, if it had not been for a meeting that took place in Yonkers, a third of a century ago.

History tells of many notable meetings and of their consequences. That unheralded one of the penniless emigrant, with a giant brain joined to a frail, deformed body, and a pioneer worker in the field of applied electricity, Edwin Wilbur Rice, Jr., had consequences of its own, far-reaching, important, and interesting alike to the layman and to the scientist. It was, in truth, an epochal meeting, for it may be looked upon as at least one of the starting points of an amazing story of material progress, the story of the development of mechanical power, in countless forms and on a stupendous scale, through the medium of electric energy.

How Steinmetz and the man who first recognized his genius are connected with that story of progress will be told presently. First let us digress enough to examine, cursorily, a few major statistics that summarize the story. They relate to central light and power stations in the United States and cover a period of twenty years. Figures for the decade previous to 1902 are not readily available; also, there are many isolated plants generating large amounts of electric power.

During the period from 1902 to 1922, the generating capacity of central stations alone was increased from 1,600,000 horsepower to 21,300,000* horsepower with an increase of capital invested from $504,000,000 to $5,100,000,000* and of annual disbursements for labor, partly estimated, from $20,600,000 to $156,000,000*.

But statistics are colorless and, except for one who habitually mulls with them, lack perspicuity. And those just given to show the rate of increase in the amount of electric current generated for commercial purposes may only cause the average reader to think of an astronomer telling of the distances between stars, or of the lamented Steinmetz himself, not when he talked to students, for he was always charmingly simple and lucid then, but when he had occasion to communicate an idea, by means of mathematical formulas, to a group of savants. Here, however, in homespun language, is what the figures tell of the

*Increase from 1922-1929 approximately 100%.

period with which they deal: There have been scattered throughout the country, connected with circuits running from central generating stations, enough arc and incandescent lamps literally to turn night into day in the urban districts. The streets of cities, and the highways connecting interurban districts with the cities and with each other, have become crisscrossed with streams of cars, deriving power from the same generating source, and daily carrying vast multitudes of passengers from place to place. In thousands of mines and factories cleanliness has been promoted, danger to human life diminished, nerve-racking noise largely eliminated, and efficiency of operation immensely increased through the installation of electric motors operated either from central generating stations or from local generating units.

What has been said relates exclusively to the generation, distribution, and use of electric power. Equally impressive has been the growth of facilities for the production of electrical apparatus. Statistics applying to manufacture are hard to find in complete and condensed form, particularly for a period as far back as the time when Steinmetz started his series of remarkable researches; and, as may again be remarked, naked figures convey little to one not an expert. A report which is handy shows that for a period as late as that from the year 1909 to the year 1922 the annual disbursements for labor by the chief

concerns of the United States making electrical machinery increased from $45,000,000 to $310,000,000.* A comparison of that kind is illuminating at least in one way; it shows how a large amount of useful labor has been provided for human brains and hands.

But what bearing, it is now time to ask, have facts such as those recited, upon the work of the scientist whose death has been so widely mourned? Here the need of being circumspect and precise becomes apparent. Like artists, as they are usually thought of, and many people, too, who could claim no artistic license, technical workers are sometimes emotional, and, to paraphrase a familiar saying, quite as prone as any class to find quarrel in a straw when credit is at stake. So it would be tactless, to say the least, for anyone giving an account of the work that Steinmetz did, not to speak of it in its relation to the work of his contemporaries. Always sane himself, the electrical wizard was among the first of those who saw sanity in Einsteinism.

The question formulated as to the relation of the work that Steinmetz did to the expansion of electrical enterprise during the past two or three decades may perhaps best be answered by a linking of two facts, one well known, the other heretofore unknown to many, including some even in the electrical industry.

*Increase from 1922-1929 approximately 100%.

In the first place, such expansion was due largely to the use of the alternating current. Secondly, it was Steinmetz, so electrical engineers everywhere concede, who made the use of the alternating current widely practicable. That much may be said without disparagement to the work of others. He was not the discoverer or originator of the so-called hysteresis law, which seems to have been known to men whose studies antedated his, but it was his clear elucidation of that law and his masterful analyses of all manner of phenomena relating to the alternating current that enabled the engineers of his day to employ effective and economical materials in their designs, and, therefore, a large share of initial credit belongs to him for the progress made during his lifetime in the commercial application of electricity.

That distinction, familiar to experts, need not detract an iota, so far as others are concerned, from the worth of what Steinmetz did. A poet, conscious of his power, once said that he cared not who made the laws of his country so long as he was permitted to make its songs. Steinmetz may, as fittingly, have said that he cared not who designed electrical machinery so long as he was permitted to state the principles upon which designs should be based. The man who, in the vernacular, does things, keeps in the limelight quite enough, or is kept there, but the importance of the original thinker who shows how to do things is sometimes overloooked. Lucky it is

for the electrical industry and the world that Steinmetz was not overlooked.

And that suggests that before we go further, more should be said of that eventful meeting at Yonkers. Rice himself, in a recent talk, described the meeting and its outcome, clearly, picturesquely, and with fervor unusual in a conservative man of affairs.

"Rudolph Eickemeyer of Yonkers," he said, "had developed some interesting designs for electric traction purposes, and certain novel and economical forms of windings for armatures of electrical machines. I was then in charge of the manufacturing and engineering of our company and my views were sought as to the desirability of acquiring Eickemeyer's work. I remember giving hearty approval, with the understanding that we should, thereby, secure the services for our company of a young engineer named Steinmetz. I had read articles by him which impressed me with his originality and intellectual power, and believed that he would prove a valuable addition to our engineering force. I shall never forget our first meeting at Eickemeyer's workshop in Yonkers. I was startled, and somewhat disappointed by the strange sight of a small, frail body surmounted by a large head, with long hair hanging to the shoulders, clothed in an old cardigan jacket, cigar in mouth, sitting crosslegged on a laboratory work table. My disappointment was but momentary, and completely

disappeared the moment he began to talk. I instantly felt the strange power of his piercing but kindly eyes, and as he continued, his enthusiasm, his earnestness, his clear conceptions and marvelous grasp of engineering problems convinced me that we had indeed made a great find. It needed no prophetic insight to realize that here was a great man, one who spoke with the authority of accurate and profound knowledge, and one who, if given the opportunity, was destined to render great service to our industry. I was delighted when, without a moment's hesitation, he accepted my suggestion that he come with us."

Much that is known of Steinmetz has already been printed. Of one thing little is known and nothing has heretofore been printed. In some respects, for some of his attainments and for his engaging personal qualities, he stood high with everyone, but among quite a few of his immediate associates, members of the technical and commercial staffs of the corporation with which his name is linked, it is doubtful if he ever had that reputation for greatness that the valuation placed upon his service after his death, showed that he had won from the world at large. These workers, most of them experts in one field, may have been bewildered by the many-sidedness of the misshapen little man who shuffled about in their midst, uprooting established ideas and planting new ones in their place; or it may be that they magnified the importance of traits that a compiler, with a

crabbed sense of justice, would feel called upon to set down as his whimsicalities or minor weaknesses.

In any event Rice, their official chief, and the man whom Steinmetz called chief, saw his remarkable protegé as they were not able fully to see him. He placed him on a pinnacle at the time of their first meeting, in the early nineties, and never doubted his right to be there, in spite of the unconventional views which he uttered on social and political subjects, in spite of his ingenuous daring in unaccustomed fields that at times made the judicious uneasy and shocked others, in spite of anything that he said or did. It was a case of a high-grade mind having a competent appraiser, a genius coming in contact with a man under whose influence it could grow and ripen. Had it not been for that happy combination there is no telling how long electrical engineers would have had to wait for the knowledge of alternating-current phenomena which was revealed to them through the work of Steinmetz.

A reader unfamiliar with the history of the electrical industry may be curious at this point as to Rice's place in it.* To say that he discovered Steinmetz is to attribute to him a feat that alone makes the world his debtor. But apart from that romantic incident his life of sixty years has been rich in achieve-

*See Chapter XII.

ment. He was chief engineer of the General Electric Company while the foundation of its success was being laid, and contributed much to that success. Later, for a period of about ten years, he served as its president, retiring from the presidency in 1922 and becoming honorary chairman of the board of directors. More than one hundred patents issued in his name attest his fertility as an inventor. Harvard University, the Rensselaer Polytechnic Institute, and Union College gave him degrees at different times, and some titular honors have also come to him from foreign governments. He was a teacher in one way as Steinmetz was in another, and many inventors and researchers, now well known, trace much of what they have done to timely inspiration received from him.

But in one respect only, it is fair to say, are these other workers, prolific though many of them have been, comparable with Steinmetz. The atmosphere that favored his genius also favored theirs. In what he was and did he was unrivalled, because altogether unique. His conceptions were unique; so were his methods; so also was his work.

Outranked by none of the scientists of his time, and deferred to by all of them, particularly as a mathematician of transcendent ability, he was never content to be even a highly honored member of any select circle, but, in such ways as seemed to him fitting, made the "fairy tales of science" familiar

and understandable to men and women everywhere. It was that intellectual democracy of his, too, that made him perhaps the most valuable single human asset that the corporation which employed him ever has had. The designing, building, and selling of electrical machinery, mainly a commercial activity at first, took on, through him, a distinct social purport. His messages and his achievements carried the meaning of electricity, as an agency of service, to the frontiers of civilization.

One word of a personal nature concerning Steinmetz is in order. I knew him well for thirty years, from the time that, as a young clerk on Rice's staff, I had occasion to prepare and hand to him for his signature the first service contract which the General Electric Company made with him, and which, if my memory is not at fault, specified $2,000 per annum as his compensation. Subsequently I had the privilege of spending many delightful hours with him at his camp on the Mohawk river and in his private laboratory. Occasionally, in recent years, I joined him in walks which it was his wont to take, after his evening meal, toward the outskirts of Schenectady, a third of a mile distant from his home and mine. The last of these walks we took a short time before he started on his trip to the Pacific coast. As we approached a convenient turning point he noticed a log at the side of the road saying,

"Let us rest there." We sat on the log, conversing, for nearly an hour, the latter part of our talk relating to his achievements.

I was the first to rise, and standing in front of him, said, "Doctor, you've had a wonderful career, and the striking thing about you is that your utterances are looked for as eagerly as those of any other living man of science. That suggests that your fitting task, say for the next ten years, will be to clothe your vision of a better world than has yet been made of our planet, in that vivid and persuasive language that you are master of. Your work henceforth will be that of a teacher."

The compliment pleased him, for his eyes lighted up with that singular luster that fascinated anyone who ever heard him speak, but his pleasure was but momentary. The massive head presently drooped, he sighed, and nervously lighted one of those panetelas that he invariably offered to visitors to his laboratory. Then, looking absently toward the distant hills, he said, in a tone that had in it a touch of pathos, "Let us go back now." No comment came from him as to his future activities, our talk, as we returned, being of other things.

It is now evident that when I spoke of ten years and of the use that he might make of them he knew it was impossible for him to survive for so long a period, and the emotional change to which I have alluded was a natural consequence of what he knew.

The idea of teaching for a decade, in itself gave him a joyous thrill; for to teach was his ruling passion, but conscious of weakening vitality, and of the fact that his brain could not outlive his body, he became unspeakably sad. For life was dear to him—as dear as it is to the children whom he loved and who listened, enraptured, to the simple stories of nature that he told them as they gathered about him Sunday afternoons on the lawn overlooking the ravine near his conservatory. With the immortal spirit of youth that was part of his genius, he looked upon death as quite a nuisance for anyone with work to do.

And Steinmetz had work to do, and, with what strength he had, did it. The labor that he performed for pay was faithfully performed, but so far as he was concerned it was incidental. His major wish was to aid in making the world efficient, orderly, beautiful, in a literal sense a pleasant place to live in, despite the fact that it could never have for him, in full measure, the satisfaction that is in it for others. The accident in infancy that left him a cripple for life, instead of embittering his nature, seemed to have given it a childlike sweetness and charm that made the inexhaustible wealth of his mind readily accessible. In the mere knack of imparting information, he is acknowledged to have been unsurpassed, and was probably unequaled, by any scientist of his time. This knack was peculiarly characteristic

of his conversation and lectures, although he ranked high as a writer, too, his textbooks dealing with electrical phenomena being standard to-day in laboratories and colleges everywhere.

Rare indeed were the intellectual gifts of Charles Proteus Steinmetz, but they were not his sole inheritance. A rare catholicity of spirit, which also was his, made the gifts a means of service, not only to industry and to science, but to mankind.

XXIX

RADIO

THE work of imaginative writers is not popularly thought of in connection with that of the world's doers, yet such work is rich in prophecy, and to some extent, perhaps, inspires the men whose names spell material progress.

Tennyson predicted a striking feature of the world war, though of course not one of which civilized men can be proud, when, nearly a century ago, he wrote of "the nation's airy navies grappling in the central blue." Jules Verne and Edward Bellamy, who provided recreational reading for multitudes during the latter part of the nineteenth century, also were more than idle dreamers. While their thoughts appeared to be either in the unexplored depths of the sea, or above the clouds, their feet were on the ground, maybe quite as firmly as the feet of the wise ones who snickered at their fantastic creations.

The submarine was anticipated in the realistic narratives of the French story teller. Like Tennyson's "argosies of magic sail," the use to which it was put during the war gave it a bad name, but it will outlive that, for men are fast learning that there is no gain or glory in mere destruction.

As for Bellamy, one now turning to his romances, and accepting their splendid spirit at its face value, finds in them little more beyond that than well-written descriptions of the coördination of human effort, and widely extended use of mechanical contrivances, which are matters of course in our day. That stirring sermon in Looking Backward was broadcast to the homes of the nation. In Bellamy's fancy it was heard by millions. One of the many surprises received by Julian West, hero of the famous novel, was that which came to him when he learned that he could listen to a religious discourse without going to church—that if he wished to do so, he could light his meerschaum, and, sitting in his den in week-day duds, hear the message of a noted preacher without any constraint to appear pious.

Thus a man who died before Marconi was heard of by anyone in America foresaw radio substantially as it is known to us. I met Bellamy upon several occasions in the early nineties, at a literary club in Boston, and recall the keen interest that he took in the physical research work which Elihu Thomson was then carrying on at Lynn.

Radio! What has been the contribution of the General Electric Company to its development? I doubt if I am qualified to answer that question, but am bound at least to try to do so, for part of the panoramic story of radio is linked to the achievements which it has been my purpose to describe.

Station WGY is located in Schenectady, a stone's throw from the great research laboratory elsewhere described. Because of that geographical advantage, and apart from the quality of its programs, it has been, from the outset, a developmental station. It has been able to obtain at first hand, daily and hourly, the results of physical research carried on by scores of alert, resourceful, and fertile engineers, with facilities at least as complete as any that can be found at one point in any other part of the world. It has systematically tested these results under operating conditions, and, in turn, supplied to the engineers information which has enabled them, through the fashioning of suitable apparatus, gradually to improve the transmission and reception of sound. Unbiased experts concede that, because of the thorough-going character and effectiveness of its purely experimental work, it has done more than any one of ninety-nine per cent of the other stations, and at least as much as any one of the remaining one per cent, to advance the radio art.

For example, station WGY has been a pioneer in the use of high power to improve broadcasting. As far back as the middle of 1925, which is a remote period in radio history, the making of which has been speedier than rabbit breeding, it demonstrated the feasibility of employing power up to 50 kilowatts and has since conducted tests with power as high as 100 kilowatts.

I had a talk only a few evenings ago about the question of high power for broadcasting with an engineer who is specially familiar with the mechanics of radio.

"High power broadcasting, to be sure, is not yet looked upon as an unmixed blessing," he said, "because, under some conditions, it curtails the usefulness of stations, operating with low power, which were constructed in the early days of radio, and of the older types of receiving sets which owners are naturally loath to discard. Nevertheless, there is bound to be a steady trend toward the use of high power, since it accords with common sense to provide the best quality of broadcasting for the largest number of people."

In the course of our conversation we made a rough estimate of the number of radio stations now using the air lanes. Complete statistics were not handy, but there appeared to be upwards of six hundred of such stations, all told, in the country. I asked just why, of all these stations, the Schenectady unit had taken the lead in the use of high power, and my companion's reply was significant.

"Primarily because such men as Langmuir and Coolidge live and work in Schenectady," he said. "Langmuir, it is true, did not invent the radio tube, as such, but it was in connection with his investigations of the electron phenomena that a much more powerful tube was developed than any which had

been known previous to such investigations. Moreover, in the construction of his improved tube, Langmuir employed ductile tungsten as invented by Coolidge. It was tungsten, with its high melting point, and the readiness with which it could be freed from gas, that greatly facilitated Langmuir's studies of the varying effects of electric current in a vacuum. Through those studies, in turn, came the knowledge necessary to produce a high-power tube. I am, of course, now speaking only of Langmuir's specific work, and only with reference to its bearing upon the service rendered by station WGY. I have no wish and no motive to ignore or disparage the work of other inventors, in America and Europe, whose contributions to radio have been outstanding. The field has been and is a wide one."

"You have stressed a point which has special interest for me," I remarked, "because I have touched upon it briefly in a sketch dealing with the conquest of tungsten—the work carried on by Coolidge to make that metal ductile. When the sketch in question was written I had the impression that, in one sense, the radio art was traceable to ductile tungsten. From what you have just said my impression seems to have been correct, that is to say, radio in the form in which it is now known, is actually linked to the conquest of tungsten by Coolidge."

"There is no doubt of it," was the reply. "You see much of the important work carried on from about the year 1910 by the two researchers mentioned has been interrelated and interdependent. In his fruitful studies of electron phenomena, Langmuir was certainly dependent upon ductile tungsten. Continuous high vacuum, with freedom from gases, a condition essential for a high-power tube, could not have been secured with any other known material. Conversely, in making his remarkable improvement of the x-ray tube, Coolidge had the advantage of Langmuir's discovery of what is known as the 'space charge' principle—the discovery that led to the production of a high-power tube."

I spoke, in a casual way, of the extended litigation which had been occasioned by differences of opinion concerning inventive priority in the case of the high-power or vacuum tube.

"The litigation must take its normal course," said the radio engineer, "but it has no bearing upon the help that station WGY has derived from Coolidge and Langmuir, to say nothing of Alexanderson, and scores of other indefatigable workers in physical research. That's the point that I understand you were considering."

"Yes, I was considering that one point alone," I replied "A record of the activities of inventors in the radio field would doubtless make a bulky encyclopedia."

The opening paragraph of this sketch refers to the influence of dreamers upon doers. The implied distinction may be misleading, for every worth-while doer is a dreamer. Owen D. Young, in a recent address, said that the physical researchers were the modern poets or makers. The researchers themselves, in the midst of their gas flames, chemicals, and world of wires, shyly smiled, but appreciated the fine compliment, and when Sunday afternoon came many of them turned to their volumes of Shakespeare and Shelley to commune with kindred spirits.

But to go back to WGY. That station has done many things for radio broadcasting, some of them in common with other stations, but in one respect its work has been distinctive: it has been a protagonist in the art, mainly because of its proximity to a nest of modern poets in which have been hatched ideas that have revolutionized forms of thought and modes of living.

XXX

A Straight Tip

THE material contained in the preceding chapters is largely historical, but that fact need not be considered disparaging, History, accurately recorded, is useful. By means of it the present, and whatever may be guessed of the future, are made comparable with the past; and comparisons are, of course, essential for an intelligent determination of procedure of any kind. Most of the things done now are a continuation of things started in the past, so that a knowledge of history is part of a normal individual's working equipment. Often the knowledge may not be carefully classified and labeled; sometimes it is no more explicit than folklore, but it is employed, consciously or unconsciously, by every member of society who is capable and efficient. What is called intuition is usually nothing more than a clear perception of the essence of history.

Nevertheless it is a fact that most folks are less concerned with yesterday than they are with to-day and to-morrow. I was particularly impressed by that fact when a friend, after reading these sketches while they were yet in manuscript form, asked, "What is to be said of the future of the General Electric Company?"

My friend was not at the moment thinking of monetary values, but the question that he asked is likely to turn the thoughts of the average reader to the stock market. The thoughts of the average reader ought not to be ignored, so I hasten to say that the stock market has interest for me as it has for him. I fervently hope that General Electric stock will in time soar to 500 or even to 1000. I own a few shares of it and confess that I am at least normally avaricious. But notwithstanding the accumulated data pertaining to the subject that one would expect me to be possessed of, I am really short on tips. As recently as last week I gave to a young man with some savings to invest the only tip that I had available, and, inasmuch as there was nothing particularly confidential about the said tip, I shall repeat it here.

"Watch the spirit of the General Electric Company," I counseled; "watch it more closely than you do the fluctuating market price of the stock. So long as it appears to you that that spirit is being kept alive, and that policies and procedures are based upon it, put your savings in the stock, and buy additional stock to the limit of your borrowing capacity. Should the spirit change or be quenched—well, then you must exercise your own judgment. I shall have to exercise mine."

That tip seemed to me as straight as most tips, but perceiving no pronounced reaction to it on the

part of my youthful auditor, I concluded that an explanatory comment was called for.

"The spirit to which the success of a corporation is traceable," I pointed out, "may, of course, be supplanted by a spirit of another sort, with continued success, perhaps on an increased scale; but that point is a speculative one. Other things being equal, a shrewd investor will stake his capital on the spirit that he knows brought success. Furthermore, a long period may elapse before the effects of a change of spirit, favorable or otherwise, become definable and calculable. The effects may seem favorable, or vice versa, till someone, normally vigilant or crabbedly curious, calls for a reckoning. Then there will be revealed in factual form evidence of unimpaired strength, or weakness—actual or potential Until then an investor's judgment is his only guide."

The youth listened patiently to my remarks, but remained unimpressed by the idea which I strove to convey. I was constrained to be, in turn, a listener as he spoke quite learnedly, and logically, too, of assets and earning power. He had taken from his vest pocket a booklet containing a large assortment of figures, which seemed to him pregnant with meaning, relative to corporate operations.

"Figures are interesting and doubtless informative to anyone who understands them," I said finally, "but so far as the General Electric Company is concerned my experience has taught me that its spirit is

its most valuable asset and its main assurance of permanent earning power. That spirit is not translatable into figures, but it is more tangible than many things that are."

XXXI

Future of Electricity; Elihu Thomson

"WHAT is to be said of the future of the General Electric Company?" The query has led me gratuitously to give the reader a tip, the worth of which is left to him to judge. As I have already explained, however, the individual who made the query, really was not thinking of the future of General Electric stock as he spoke. He was interested rather in the future of electricity.

The future of electricity is a fascinating theme, and a most important one, too, so important that it will be dealt with here through the medium of a man whose name will at once suggest competent authority. The man is Elihu Thomson, already referred to in this volume as one of the fathers of the General Electric Company, and a physicist and inventor of renown.

Little can be told of that shining light of a great profession that is not known to most of its members throughout the world. In 1877, at the early age of 24, he gave a series of five lectures at the Franklin Institute in Philadelphia, and in the course of one of them reversed a Rhumkorff coil by sending a Leyden jar discharge through its fine or secondary wire, thereby producing a heavy current in its thick or

primary wire. That demonstration probably was the starting point of the development, by him and others, of the important auxiliary of an electrical distributing system known as a transformer. Moreover, it suggested to the young investigator the principle of electric welding, which he subsequently applied. The installation and successful operation by him of an arc lighting system in a Philadelphia bakery—mentioned earlier in this narrative—followed two years later, in March 1879. Pages would be required merely to catalogue his contributions to the electrical and kindred arts since that remote period. More than seven hundred patents for inventions covering methods of electrical generation and distribution, and electrical and other processes and devices, have been issued in his name. It is doubtful if he is able to remember all of the medals and other tokens of honor that have come to him from scientific bodies, in this country and in Europe, for work of conspicuous value.

When I first met him, in 1889, I was struck by his engaging simplicity, a trait which has made him universally beloved. His manner was earnest, but as natural as that of an unsophisticated youth. It was obvious that, intellectually speaking, he was anything but unsophisticated; his fund of knowledge was extraordinarily large, but a sustained eagerness to add to it kept him youthfully receptive. Then, too, what a charming style he had of imparting to others

what he knew! It was more like the style of a kindly teacher than that of a preoccupied scientist.

The workers by whom he was surrounded called him "Professor." As we have already seen, he had been a teacher of chemistry and physics in the Boys' Central High School of Philadelphia. He has been invested with many titles since 1889, but the designation by which he was then known to me is the one through which I am now best able to visualize him.

The basic importance of the Professor's work is so familiar to electrical engineers that, as I have already indicated, anything said of it is likely to seem to them trite. Nor is it by any means unfamiliar to the public. Electric welding, for example, patents for which were granted to him more than forty years ago, has had countless useful applications. Its value has been strikingly illustrated in recent years in the construction of automobile bodies as well as of turbine and other heavy machines. Office and factory buildings with electrically welded framework are now not uncommon.

The Professor, however, has always been a quiet worker. While there are many things that he likes, one thing that he cordially dislikes is charlatanism of any sort. No one ever has been encouraged by him to give a stagey glamour to his achievements. Reporters have found him friendly and communicative, but averse to sensationalism. Many re-

searchers not more diligent than he has been, and many inventors not more fruitful, have been featured oftener in newspaper headlines. On the other hand, none of them has had a greater measure of recognition than has come to him from the men whose words have weight in the inner circles of science.

So he was running true to form when, at the outset of my last conversation with him, he said:

"The electrical art has not been enriched in recent years by the discovery of any new principles of dynamo construction."

Having in mind at the moment the average layman's picture of the wonders of electricity, which is not, of course, a very clearly defined picture, I took that assertion as a slip of the tongue. Upon reflection, however, I perceived that it was literally correct. The principles of dynamo construction are the same now as they were a quarter of a century ago. There can be no doubt of that. The quoted statement merely illustrates the care which the Professor habitually exercises to avoid misleading anyone. He is an interesting conversationalist and writer, but believes that whatever story is to be told can best be told through a discriminating recital of facts.

"For the most part," he went on, "engineers have been concerned with the efficient production and distribution of electric energy, that is to say, their efforts have been exerted largely to improve forms of construction based upon principles set down in text-

books. Anyone who examines an electric generating mechanism beholds a moving part, or rotor, and a stationary part, or stator, and, from his knowledge of accepted theories, as well as effects repeatedly produced, understands in a general way what takes place in the mechanism. There has been no marked change even in the materials of which the mechanism is made. Copper is still the best conductor of electric current. Iron, in one form or another, still provides the best magnetic field. The great bulk of the inventions for which patents have been granted relate to arrangement of parts of the mechanism, to form, size, and location of conductors, systems of conversion and distribution, methods of insulation to prevent leakage or waste, and so on. In the quest for the most effective combinations, copper and iron and a multitude of other materials have been analyzed and tested under all sorts of conditions, and notable improvements have been obtained through the employment of alloys as well as by tempering, welding, and other processes. In brief, while the accomplishments in the electrical field in recent decades have on the whole been truly wonderful, most of them have consisted mainly of improvements of design. Generating and distributing apparatus is much simpler in construction than it was in the early days; it is much lighter; its cost is much lower. And to that condition—to the results of cumulative effort to perfect details—must be attributed much of the

increase in the number of uses that have been found for electric energy.

"Now, there is bound to be an increase of the number of these uses in the years to come. Maybe the rate of increase will be greater in the future than it has been in the past. And that brings us to your point. You ask me to turn from research work, which is my trade, to the making of predictions, which is a trade of another kind. Of course, it is easy to make predictions, and we know that some predictions fail to be realized. False prophets, like the poor, we always have with us. All that I can consistently do is to speak of the future in the light of such knowledge as I have of the present. Here, then, are a few of the things that in my judgment may be classed as probabilities or possibilities of the next five, twenty-five, or fifty years—I cannot be more explicit than that as to time, since rate of progress of any kind varies with conditions:

"1. The substitution by the railroads of electric for steam power. Railroad electrification seems thus far to have been unwarrantably slow, but with its economic and other advantages obvious, it will come about fast enough, so fast as to tax the facilities available for producing necessary equipment.

"2. Illumination of state highways. With the ever-increasing use of the automobile, and the reduced cost of light, resulting from the invention of the gas-filled lamp, together with improved methods of

manufacture, highway illumination on a greatly extended scale is inevitable. Having equalled the Romans as road builders, and probably excelled them, it remains for us to apply the means, which we have and which they lacked, to make traffic after sundown pleasant and safe.

"3. Electric propulsion of ships—that is to say propulsion through an electric generating and distributing system, operated either by steam, with coal or oil as fuel, or by a suitable internal combustion engine, gas or oil. Of course there have been a number of applications of electric energy to the propulsion of ocean-going ships, starting with the equipment of one of its colliers by the United States Navy in 1912 or 1913. But from now on, applications will multiply, because the electric drive has become increasingly reliable, due to marked progress made in recent years in the solution of problems of control, and because of reduced cost of equipment as well as reduced operating cost.

"4. Aircraft electrification. When I speak of aircraft electrification I, of course, am not fancying an electric substitute for the gasoline engine, although with increased knowledge of the nature of electricity aircraft propulsion, through some form of electric energy, may become entirely feasible. From the information which has been obtained through intensive study of atoms and molecules, it is hard to escape the conclusion that, in the last analysis, all energy in

matter is electric, or, in other words, is a result of interaction of the elements of which matter is composed, the interaction giving rise to the mysterious phenomena called positive and negative charges. This principle applies as well to the smallest conceivable particle of matter as to the earth and to the universe itself. Hence it may be assumed that all that we need in order to be able to run an airplane by electricity is a fuller understanding of that principle than we yet have.

"Electric propulsion of aircraft must, however, be classed as one of the problems yet to be solved. At the moment I am thinking specifically of suitable electric mechanisms through which to set the existing type of motor going, as well as to regulate and control flight. An electric starting device, like that which has been perfected for the automobile, will soon come, and electric instruments to indicate direction and location are on the way or have arrived. Uncertainty of location in a fog, with the possibility of striking a mountain, invisible to an aviator till he is too close to it to ascend to a safe altitude, heretofore has been one of the major hazards of air travel. With an instrument which has already been developed to indicate nearness of land, or remoteness thereof, that hazard will be removed or greatly minimized.

"But the uses of electric energy in aviation need not be dwelt upon in detail; many of them may readily be imagined. Broadly speaking, such energy

in one form or another is bound to be an important feature of aircraft evolution.

"5. Heating and cooling of buildings and extended use of domestic appliances. So far as suitable mechanism goes, and so far as results go, the heating of houses by electric energy is now a simple procedure. Obviously, what makes it impracticable in the colder climates is the cost of the energy. Cost of energy need not, however, be classed as a permanent limitation. There has been a threefold increase, in a relatively short period, of the energy of oil or coal going into power produced in power plants, and we may expect a continued increase of efficiency, or lowering of cost, through improved design of machinery as well as through utilization of waterfalls on an enlarged scale. Furthermore, the cost of electric energy may be at any time cut twenty-five or fifty per cent, or more, through the discovery of some new electromagnetic principle, or some new material.

"The attention given to the cooling of offices, workshops, and dwellings during the hot summer months has heretofore been sporadic, and on the whole meager, but the interest of engineers has been stimulated in the subject by the remarkable success of the electric refrigerator. Relief from the stifling heat and humidity of July and August, possibly through some application of the electric refrigerator principle, cannot be far off.

"In short, there is nothing chimerical in assuming that the temperature of the indoor spaces in which the vast majority of men and women, rich and poor alike, live and work, will soon be raised or lowered, as may be desired, by the pressing of an electric button, or through the operation of a thermostat.

"As for domestic appliances, it is a fact that electric ranges, washing machines, vacuum cleaners, irons, and toasters are now nearly as familiar to city dwellers as furniture, rugs, and tableware. They are not wholly unfamiliar in rural communities. Their universal use is but a question of time.

"6. Electrification of farms. If, as the statisticians tell us, only five per cent of the six and one-half million farms of the country are now supplied with electric energy from central stations, it is obvious that agriculture has not yet had anywhere near its share of the advantages of electricity. In this case again cost has been the limiting feature of growth, but it cannot continue indefinitely to be the limiting feature.

"Apart from the cost of producing electric energy, as already touched upon, the cost of making such energy available for use in the open spaces devoted to agriculture has been appreciably reduced in recent years through the erection of substations, with step-down transformers for the distribution of current, at low voltage, over wide areas. The latest cut in the cost of transmitting electric energy has come through

the introduction of a device to which the name series-capacitor has been given. This device may be likened to a transformer when one thinks of transfer of power in a system of electrical distribution, but it functions differently from a transformer. The series-capacitor, instead of raising or lowering pressure, prevents or compensates for the loss of pressure which results from a choking effect, technically known as inductive impedence, which is normal in an alternating current line. Equitable charges for service, too, are, I understand, being insured through scientific rate-setting.

"With the convenience and economy of the refrigerator and range recognized by his wife, the farmer will have one incentive which he has not had in the past, to coöperate with the central station in its effort to make electric energy available to him at reasonable cost; and when the energy is available for operating a refrigerator and a range, he will want to apply it to such work as hoisting of hay, milking of cows, and so on. Electric energy is now employed, on the farms that comprise the five per cent which are electrified, in the performance of numerous classes of arduous labor."

The Professor touched upon several other fields in which he thought the use of electric energy would be greatly extended. He was an optimist forty years ago, a constructive optimist, and remains one. His repeated reference to cost as a controlling factor of any estimate of future expansion led me to ask him

to enlarge upon the ways in which the cost of electric energy was likely to be reduced.

"Forms of electric machines will continue to be modified," he said. "Methods and processes of manufacture will be improved, systems of transmission will be simplified. Moreover, we may at any time find in nature new materials, or we may be able, through new processes of separation and fusing, to produce combinations of known materials, which will be more economical and effective for our purposes, as electrical engineers, than any now used. While we cannot, any more than could the alchemists, transmute base metals into gold and silver, it is a fact that we are constantly imparting to many metals characteristics which they do not possess in their original state and which add greatly to their usefulness. We are doing so by alloying them with other and formerly rarer metals, as well as by means of heat treatment, in specially constructed furnaces, and by sundry forms of manipulation.

"Tungsten, for example, had only a very limited use till we learned how to make it ductile. Now its use is felt wherever there is artificial light.

"Another example, perhaps not so striking, is that of quartz, which is a crystal and not, like tungsten, a metal. We expect through a special heat treatment to make from this crystal a mirror which will render possible the construction of a telescope four times more powerful than the most powerful telescope now

in existence, and possessing properties of far more value in use. Thus, through the instrumentality of so common a substance as quartz, information may be revealed as to the chemistry of the universe of vast consequence to mankind. Perhaps the information will aid us better to understand what electricity is, or does, and even to find a clue to the mysteries of life itself.

"One feature of quartz, which should give it much commercial value, is that it possesses therapeutic virtue as a substitute for glass in the windows of hospitals and dwellings. Unlike glass, it does not obstruct the ultra-violet rays which are beneficial to an invalid, or to anyone, sitting under the sun on a veranda or on the seashore. On the other hand, a room with quartz windows may be artificially heated in winter quite as readily as one with glass windows."

"But to go back to electricity," the Professor concluded, "I spoke a moment ago of the possible discovery of some new electromagnetic principle. We know now that by revolving a mass of material, which is called an armature, in a magnetic field, we set up a force with which we are able to light cities or run railroad trains. We do not know intimately what takes place in a dynamo when current is generated there. Perhaps we would know if we could once become familiar with the actual constitution of material atoms. Our theory is that with the revolution of the armature, as indicated, electrons are re-

leased, that the released electrons cause others to be released, and that the interaction of these tiny bodies as they dart about at unthinkable velocity, colliding with one another and raising a general disturbance, gives rise to the free energy referred to, which is called electricity. An atom is known to contain a vast store of potential energy, of which we have been able thus far to make available but an infinitesimally small portion. Who can say that some day, far in the future perhaps, man shall not acquire control of that energy in some atomic combinations, formerly called 'elements', and utilize it as he now utilizes power produced in a power plant!"

XXXII

Grand Young Man

MAYBE I have not given an adequate answer to the question "What is to be said of the future of the General Electric Company?" The fact is that I have not attempted to give any answer. It has seemed to me more fitting to present the views of Elihu Thomson as to the future of electricity than to dwell upon current problems of a financial and administrative character. In a creative sense he personifies the General Electric Company. Had it not been for him it would not be in existence, at least in the form in which we know it. From his early work one of its major roots drew its substance. No other employee has served it for so long a period, nearly half a century.

In his published biography, 1853 is given as the year of the Professor's birth, so he is 76. One wishing to apply to him a term of endearment might call him the grand old man of the electrical industry, but to speak of him as its grand young man would be more in keeping with his achievements, point of view, and spirit, and with his power, even as a septuagenarian, to inspire affection in the men with whom he works.

"What is to be said of the future of the General Electric Company?" Much could be said, but all that seems to me appropriate to say here may be said in a sentence or two. The future of the General Electric Company will depend upon the men who in the years to come are to control the institution, direct its activities, and be responsible for the preservation of its spirit. If they are to be men of the caliber of Elihu Thomson and others who, with him, did much to make it what it is, there need be no misgivings as to its future. It will continue to do worth-while things and on that account continue to prosper.